FAA-E-2996
April 1, 2008

DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

PERFORMANCE SPECIFICATION

DISTANCE MEASURING EQUIPMENT (DME)

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

1.0 SCOPE

Scope. This specification covers requirements for solid-state ground station distance measuring equipment (DME) suitable for use in the National Airspace System (NAS) in conjunction with en route and terminal navigation aids. This type of DME is known as DME/N where the "N" stands for narrow spectrum characteristics.

2.0 APPLICABLE DOCUMENTS

General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.1 Government Documents.

Specifications, Standards, and Handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

MIL STANDARDS

MIL-STD-461E - Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.1.1 Other Government Documents, Drawings, and Publications.

The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

SPECIFICATIONS

FAA

FAA-G-2100H - Electronic Equipment, General Requirements

ORDERS

FAA

Order 6050.32 - Manual of Regulations and Procedures for FAA Spectrum Management

FAA ADVISORY CIRCULARS

AC150/5345-43 - Specification for Obstruction Lighting Equipment

2.2 Non-Government Publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents, which are Department of Defense (DoD) adopted, are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation.

INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO)

ICAO Annex 10, Vol. 1, 6th ed. - International Standards, Recommended Practices and Procedures for Air Navigation Services, Aeronautical Telecommunications

(Application for copies should be addressed to the International Civil Aviation Organization, Document Sales Unit, 999 University Street, Quebec, Canada H3C 5H7.)

2.3 Order of Precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated specifications or specification sheets), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3.0 REQUIREMENTS

3.1 General Requirements.

3.1.1 Modular Construction. Construction with plug-in or easily replaceable sub-assemblies (i.e., no special tools required) shall be used throughout the equipment in order to provide the specified level of maintainability. Modularization shall be based on logical functional block concepts. Design shall be such as to minimize the cost and number of different types of modules required for equipment support. Modules shall be printed circuit boards whenever practical from the standpoint of component size weight and consistent with circuit performance requirements. The DME system shall meet all the requirements in FAA-G-2100 paragraph 3.1.2.4.3, least replaceable units.

3.1.2 Primary Power Source. The transponder equipment shall operate from a nominal 120/240 Volt, 60-Hertz primary power source. The design center-voltage (3.1.1.7 of FAA-G-2100) shall be 120 Volts.

3.1.3 Solid State Design. All active electronic devices shall be semi-conductor devices or micro-electronic devices. Tubes shall not be employed.

3.1.4 Test Points and Connectors. Each component of the ground station equipment shall contain test points and connectors, appropriately labeled and numbered as necessary, to provide for the examination of significant voltages, signal amplitudes, waveforms, and timing characteristics and to provide for the connection of test equipment for adjustment and maintenance operations. The type of test points and connectors provided shall be compatible with the applications for which the test points and connectors are needed. All test points and connectors shall be accessible with adequate visibility and clearance from adjacent objects to permit safe and unhampered connection of cables and probes. Connection to test points and connectors utilized in either adjusting or testing the DME for proper performance during prescribed periodic (or non-periodic) maintenance shall necessitate no interrupting the operation or use of the DME. Test points on plug-in printed circuit boards shall be located on the outside edge of the board if access is required for periodic maintenance.

3.1.5 Interlock Signal from the Instrument Landing System (ILS). The transponder equipment shall be capable of accepting a remote interlock signal from an ILS localizer. The transponder shall be put in standby (not radiating) when the interlock signal is absent and automatically start operating (radiate) when the signal is present, if otherwise enabled.

3.1.6 Battery Backup. The transponder equipment shall have a continuously engaged backup power supply that enables normal operation for a minimum of 4 hours subsequent to a failure of the primary power source with fully charged batteries.

3.1.7 Equipment Cabinet. The DME equipment cabinet shall be sized so that it will fit easily into shelters, leaving room for workspace, co-located equipment such as an ILS, and adequate space for personnel. Equipment cabinets shall be FAA standard 19-inch rack size or smaller.

The rack or cabinet shall be steel or aluminum. If floor mounted, easily accessible holes in the base shall be provided for attaching the bottom of the rack to the shelter floor. If wall mounted, mounting holes shall be provided for attaching the cabinet to wall mounted Unistrut or similar material. The wall-mounted cabinet shall provide access to the rear of the cabinet. The rack or cabinet shall allow the installation of as many as four conduits of up to 2-1/2 inch size for AC power, battery, ground, and signal cables.

3.1.8 DME Purpose. The DME system shall provide for continuous and accurate indication in the cockpit of the slant range distance of an equipped aircraft from an equipped ground reference point.

3.1.9 Range. The system shall provide a means of measurement of slant range distance from an aircraft to a selected transponder to the limit of coverage prescribed by the operational requirements for the selected transponder.

3.1.10 Coverage. When associated with a Very High Frequency Omnidirectional Range (VOR), DME/N coverage shall be at least that of the VOR to the extent practicable. When associated with an ILS, DME/N coverage shall be at least that of the respective ILS.

3.1.10.1 Omni-directional Coverage Volumes. Figure 1 shows the minimum coverage volume for a DME with an omni-directional antenna and a preset power level of 1000 Watts. Figure 2 shows the minimum coverage volume for a DME with an omni-directional antenna and a preset power level of 100 Watts.

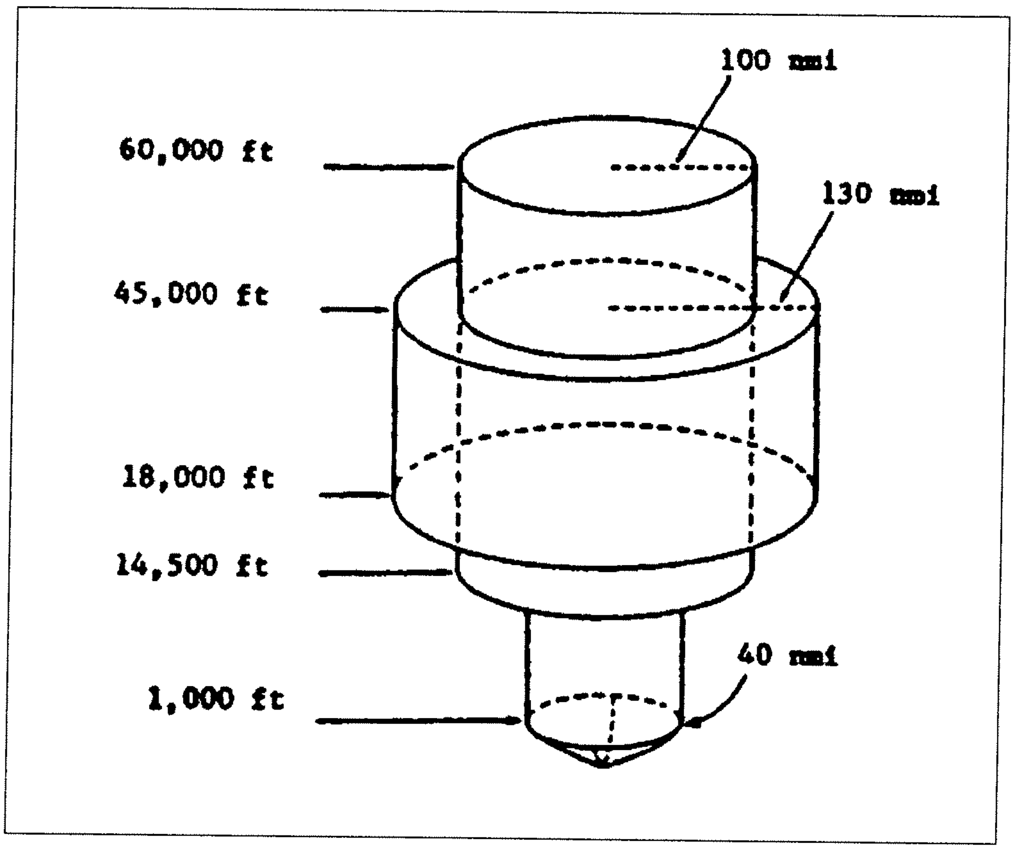

Figure 1. Omni-directional 1000 Watt Coverage Area

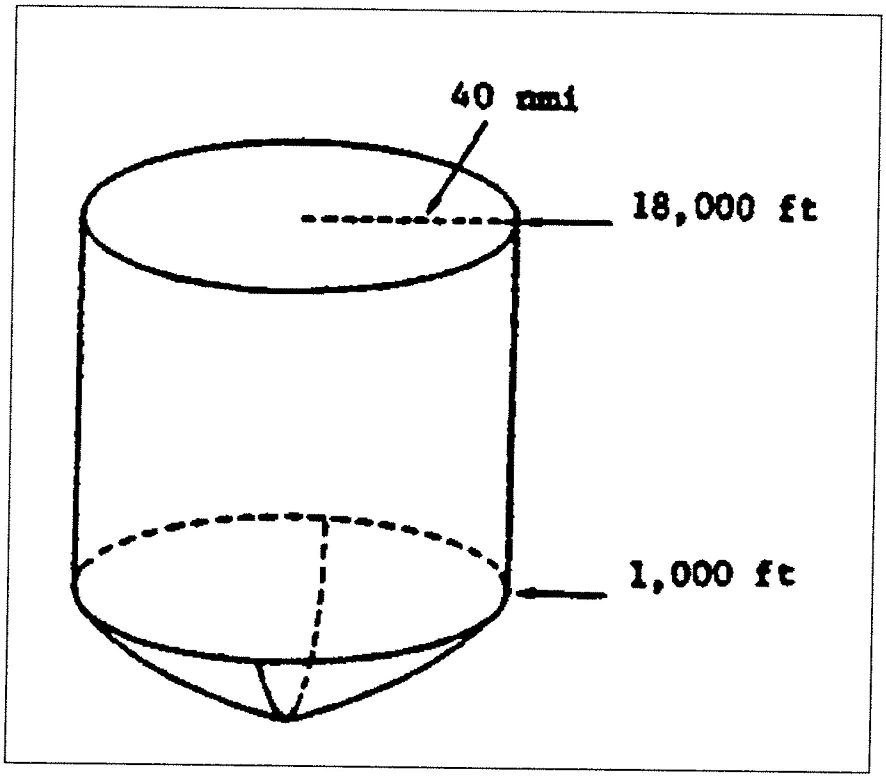

Figure 2. Omni-directional 100 Watt Coverage Area

3.1.10.2 Directional Coverage Volumes. Figure 3 shows the minimum coverage volume for a DME with a bi-directional antenna and a preset power level of 100 Watts. Figure 4 shows the minimum coverage volume for a DME with an uni-directional antenna and a preset power level of 100 Watts.

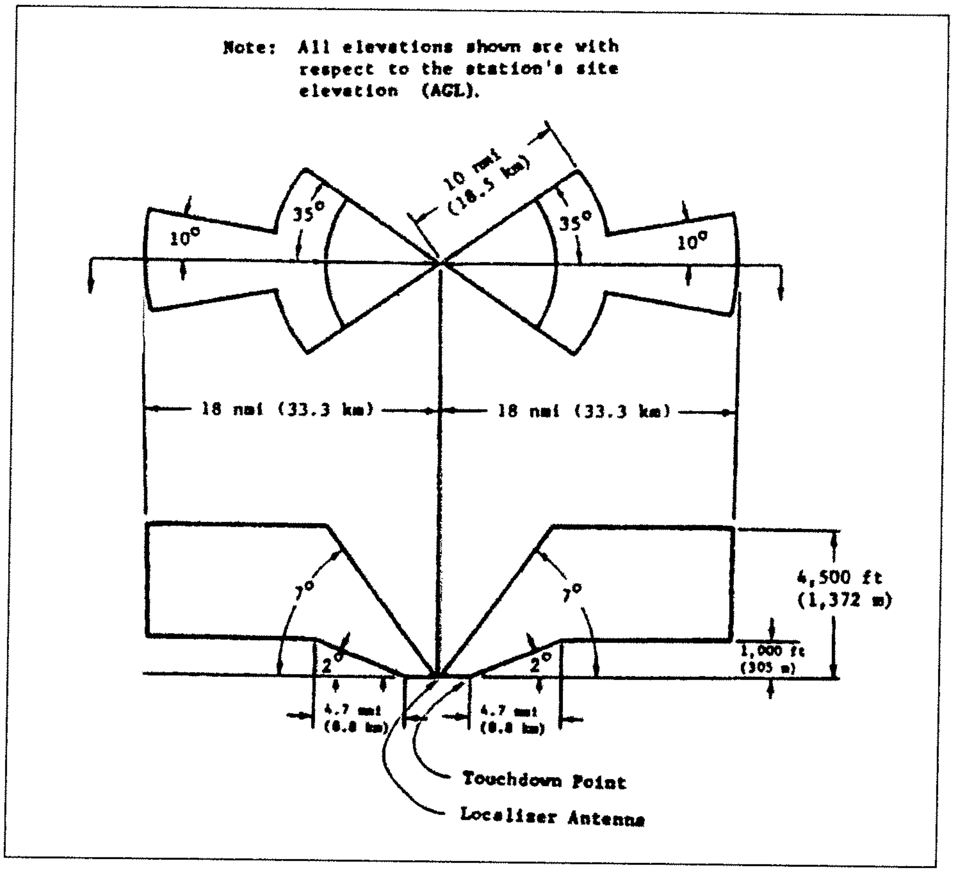

Figure 3. Bi-directional 100 Watt Coverage Area

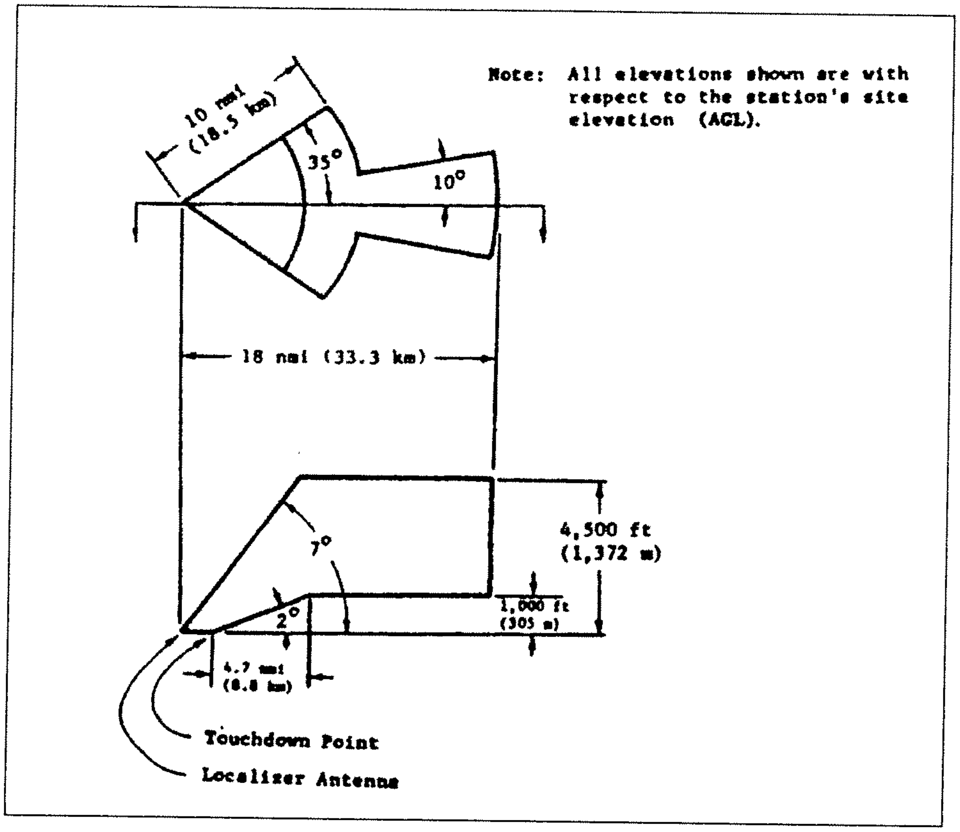

Figure 4. Uni-directional 100 Watt Coverage Area

3.1.11 Accuracy.

3.1.11.1 System Accuracy. The accuracy standards specified herein shall be met on a 95 % probability basis, which is the accuracy that must be within the error limit for 95 % of the time in any 40-second evaluation window as shown in Figure 5.

Note: The total system limits include errors from all causes such as those from airborne equipment, ground equipment, propagation, and random pulse interference effects.

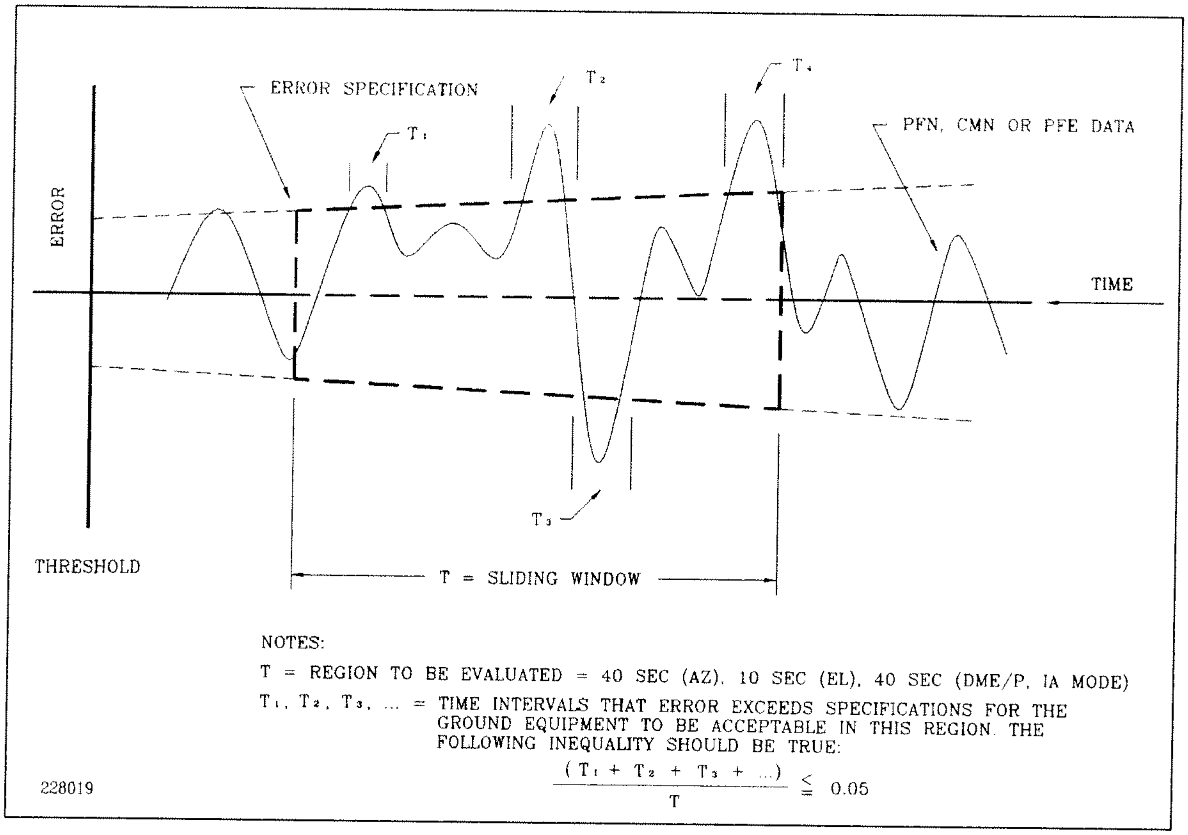

Figure 5. Methodology for Assessment of 95 % Criteria

3.1.11.2 DME Accuracy. The total system error shall not exceed plus or minus 370 m (0.2 nmi).

Note 1: This system accuracy is predicated upon the achievement of an airborne interrogator error contribution of not more than plus or minus 315 m (0.17 nmi).

Note 2: In mixed DME/N and DME/P operations, it is intended that the total system error be not greater than plus or minus 460m (0.25nmi) plus 1.25 % of the distance measured.

3.1.11.3 Transponder Capacity. The minimum aircraft handling capacity of the transponder shall be adequate for peak traffic of 200 interrogators with an average interrogation rate of 30 pulse-pairs per second (ppps) and a transponder reply efficiency of 70 %. DME ground components shall provide slant range adequate for a minimum peak traffic load of 4800 transmissions per second.

Note: This specification is intended to be consistent with ICAO Annex 10, Attachment C to Part I, paragraph 7.1.5. The referenced requirement in Annex 10 is specified in terms of the number of aircraft, where each aircraft is assumed to have a single interrogator.

3.1.12 Maintainability. The mean time to isolate and replace a faulty Lowest Replaceable Unit (LRU) shall not exceed 30 minutes. In no case shall the time required to isolate and replace a faulty LRU exceed 120 minutes. These time requirements assume the following: a single maintenance technician performs the repair; the technician has had adequate equipment-specific training; and, the repair work is performed under normal conditions in the equipment shelter.

3.1.13 Reliability. The DME system shall have a mean time between failures (MTBF) of not less than 8760 hours as a serial reliability model.

The MTBF for a particular interval shall be the functional life of the system divided by the total number of failures within the system during the measurement interval.

3.1.14 Continuity of Service. The continuity of service of the DME (expressed as a probability of not losing the radiated guidance signals) shall be equal to or greater than .999996/ 1, which is equivalent to -(4 x 10^{-6}), with an exposure time of 120 seconds.

3.1.15 Integrity of Signal. Integrity of the signal (expressed as a probability of not radiating false guidance signals) shall be equal to or greater than 0.9999999 / 1, which is equivalent to -(1 x 10^{-7}).

3.1.16 Security Requirements. The contractor will ensure that appropriate security safeguards are incorporated into the equipment as described below.

3.1.16.1 Data Security. The DME system shall contain features in its design and operation that prevent unauthorized and disruptive access to the system by implementing the following requirements as a minimum:

a. Authorized user access verification;
b. User password control;
c. Restriction of access to system/operating system (OS) files/data;
d. Denying access to direct OS functions/commands;
e. Logging of unauthorized system access attempts;
f. Limited access to specific functions based on job category;
g. While in the normal operating mode, prevent the loading of data from removable media or network connections;
h. Disable any unused ports during normal operation.

3.1.17 Operational Environmental Conditions. The DME system shall comply with the requirements given in FAA-G-2100, paragraph 3.2.1. Additionally, those parts of the equipment that are designed to be installed inside a building or equipment shelter shall meet this specification under the following conditions:

a. An ambient temperature range of –10 C to +55 C indoor and –50 C to +70 C outdoor;
b. A relative humidity of

1. 95 % for temperatures of +35 C and below
2. 60 % for temperatures above +35 C;

c. An atmospheric pressure down to 840 millibars.

All components shall operate within their rating over the ambient temperature range specified in a. above.

3.1.18 Electromagnetic Interference (EMI). The DME equipment shall be designed to meet the electromagnetic susceptibility and emission requirements of MIL-STD-461 Section 5, paragraphs 5.5, 5.6, 5.8, 5.16, and 5.19 as required by FAA-G-2100. In addition, the design shall provide the shields necessary to protect personnel.

The equipment manufacturer or supplier shall obtain Federal Communication Commission (FCC) type acceptance in accordance with FCC Rules and Regulations, CFR, Title 47, Part 2, 15, and 87. For equipment designed for connection to either the public or private telephone networks, the contractor shall obtain FCC Registration in accordance with FCC Rules and Regulations, Part 68. All components of the Remote Maintenance Monitoring (RMM) subsystem and any other microprocessors shall meet the requirements for Class A computing devices in accordance with subpart J, Part 2 of the FCC Rules and Regulations.

3.1.18.1 Electromagnetic Compatibility (EMC). In addition to the requirements of FAA-G-2100, paragraph 3.3.2, electromagnetic compatibility (EMI/EMC), the vendor shall meet the requirements of CFR Title 47 Part 87 (Telecommunications Commission, Part 87, of the FCC Rules and Regulations) for all equipment that radiate in the frequency bands protected for radio navigation.

3.1.19 Operation of Overload Protective Devices. The DME system shall meet the requirements given in FAA-G-2100, paragraph 3.1.1.6, circuit overload protection. Additionally, any overload protective devices other than fuses and primary power circuit breakers shall be capable of being electrically reset through action of the control equipment required in paragraph 3.5.

3.1.20 Static Discharge. The DME system shall meet the requirements given in FAA-G-2100, paragraph 3.2.6, static discharge.

3.1.21 Grounding and Bonding. The DME system shall meet the requirements given in FAA-G-2100, paragraph 3.1.1.9, Grounding and Bonding.

3.2 Transponder Requirements.

3.2.1 Operating Channels. The transponder shall transmit on the reply frequency appropriate to the assigned DME channel without physical equipment modification or special test equipment. DME operating channels shall be chosen from ICAO Annex 10, Volume 1, Chapter 3, Table A (or FAA Order 6050.32 Appendix 3, Section I); i.e., 252 channels in which the channel numbers, frequencies, and pulse codes are assigned. The appropriate DME channels shall be able to be assigned and changed without any physical modification of the system (i.e., changing of crystals) within 30 minutes without special tools.

3.2.1.1 Channel Frequency and Stability. The radio frequency of operation shall not vary more than plus or minus 0.001 percent from the assigned frequency.

3.2.2 Receiver and Video Circuitry. All performance requirements specified herein of paragraph 3.2.2 that involve DME interrogation signals shall be met when the interrogation signals have any combination of characteristics set forth under paragraphs 6.1.1.1 through 6.1.1.5 (Definition of Interrogation Signal) and, unless otherwise indicated, when the signals occur at levels from the threshold sensitivity level to not less than –10 dBm as referenced to the transponder antenna transmission line connector.

3.2.2.1 Receiver Bandwidth and Stability. The minimum permissible bandwidth of the receiver shall be such that the transponder sensitivity level shall not deteriorate by more than 3 dB when the total receiver drift is added to an incoming interrogation frequency drift of plus or minus 100 kHz in the opposite direction.

3.2.2.1.1 Receiver Bandwidth. The receiver bandwidth shall be sufficient to allow compliance with DME accuracy requirements when the input signals are those specified in paragraph 6.1.1.

3.2.2.2 Receiver Decoder. The transponder shall include a decoding circuit such that the decoder shall decode and produce an output pulse from interrogation signal pulse pairs occurring at spacing within the range of 12 ±0.5 μs for channel numbers ending in the suffix X and 36 ±0.5 μs for channel numbers ending in the suffix Y.

3.2.2.2.1 Decoding Circuit Performance. The decoding circuit performance shall not be affected by signals arriving before, between, or after the constituent pulses of a pair of the correct spacing.

3.2.2.2.2 Decoder Rejection Pulse Spacing. When the interval of a pulse pair varies from the nominal value by ±1 μs and if there is no other interrogation, the threshold sensitivity shall not be reduced by more than 1 dB. An interrogation pulse pair with a spacing of plus or minus 2 μs, or more, from the nominal value and with any signal level up to the value specified in 3.2.2.6.3 shall be rejected such that the transmission rate does not exceed the value obtained when interrogations are absent. When the spacing differs by ±3 μs or more from nominal value, the reduction in sensitivity shall be at least 70 dB with respect to 3.2.2.6.

3.2.2.2.3 Decoder Rejection Pulse Width. The decoder shall provide a minimum of 70 dB rejection to paired pulses with spacing of 11.5 to 12.5 μs for X channel and 35.5 to 36.5 for Y channel, where either pulse has a width of 0.8 μs or less. The decoder shall provide a minimum of 70 dB rejection to single pulses of any width including widths within 11.5 to 12.5 μs for X channel and 35.5 to 36.5 for Y channel.

3.2.2.3 Receiver Dead Time. Each decoded pulse (3.2.2.2) shall result in the generation of a dead time interval during which time the transponder shall not reply to any other signal at any and all levels up to –10 dBm. The dead time interval shall be adjustable throughout the range of 50 to 150 μs. With the exception of the number of decoder receiver noise pulses permitted under 3.2.2.9, dead time shall only be generated by received and decoded interrogation pulse pairs.

3.2.2.4 Receiver Recovery Time. The recovery time of the receiver and its associated video circuitry shall be such that the threshold sensitivity to desired interrogations is not reduced by more than 1 dB when desired interrogations occur 8 μs and more after the reception of undesired pulses having all levels up to 60 dB above the threshold sensitivity of the receiver in the absence of such undesired pulses. The desired interrogation shall be Radio Frequency (RF) pulse pairs conforming to the characteristics defined in paragraph 6.1.1 and the undesired pulses shall conform to the same requirements except that the pulse spacing shall be outside the limits of 3.2.2.2 (such that dead time is not generated). The 8 μs spacing shall be measured between the 50 percent voltage point on the leading edge of the second pulse of the undesired pulse pair and the corresponding point in the leading edge of the first pulse of the desired pulse pair. This requirement shall be met with echo suppression circuits, if any, rendered inoperative.

3.2.2.5 Echo Suppression.

3.2.2.5.1 Short Distance Echoes. Synchronous pulse signals occurring between the pulse pair of the direct-path interrogation and superimposed on either the leading or trailing edge of the second pulse of direct-path interrogation shall not affect the time of decoding for the direct-path interrogation by an amount in excess of 0.15 μs. The presence of such synchronous pulse signals shall not cause the reply efficiency to be reduced by more than 10 % from that measured in the absence of the pulse signals. These requirements shall be met when the RF input signal level of the direct path pulse pair has any level from 10 dB above the sensitivity threshold triggering level to an absolute level of –10dBm and the echo pulse has any level up to the level of the direct pulse pair and for all direct pulse pair spacing of paragraph 3.2.2.2 in this document.

3.2.2.5.2 Long Distance Echoes. Continuous wave (CW) and echo suppression shall be provided for interrogations having echoes that are delayed with respect to the direct-path interrogation in excess of the receiver dead time setting. The decoding of a direct-path interrogation pulse pair shall trigger the echo suppression pulse whenever the level of the direct-path pulse pairs exceeds a pre-established level (i.e., triggering level). The echo suppression function shall provide the following:

a. The triggering level shall be adjustable to any level between –80dBm and –10 dBm;

b. Triggering shall result in a receiver desensitization pulse that shall start at the time of the pulse decoding and shall be active for the duration of the echo suppression pulse;

c. The duration of the echo suppression pulse shall be adjustable over the range of 50 through 350 μs;

d. The degree of receiver desensitization (i.e., desensitization level) shall be to a level 3.0±3 dB above the level of the decoded direct-path pulses and shall be active for the duration of the receiver desensitization pulse, unless re-triggered pursuant to the specifications given in f. below;

e. The dynamic range of the receiver desensitization shall be capable of providing the degree of desensitization specified in d. above for signal levels at the minimum triggering level to –10 dBm; and,

f. When active, the echo suppression function shall be re-triggered whenever a pulse pair, with a signal level that exceeds the current desensitization level, is decoded. In this case, the receiver desensitization level shall be re-adjusted to a level 3.0±3 dB above the level of the newly decoded pulses and shall hold over the entire duration of the echo suppression pulse unless retriggered by a signal stronger by 0 to 6 dB than the direct path signal and over a range of input signal from 10 dB above threshold triggering level to –10 dBm.

Note: In this context, echoes mean undesired signals caused by electromagnetic scattering of the interrogator signal (e.g., multipath transmission, reflections, etc.).

3.2.2.5.3 Echo Suppression Disable. When the transponder is in normal operation, the long and short echo suppression feature shall be disabled and the receiver returned to its un-desensitized level for the duration of the monitor generated interrogation pulse pair. This feature shall be selectable.

3.2.2.5.4 DME Traffic Load Monitoring. Outputs shall be provided for local and remote monitoring of the total number of decoded pulse pairs per second and the number of echo suppression desensitization pulses triggered per second.

3.2.2.6 Receiver Sensitivity. In the absence of all interrogation pulse pairs, with the exception of those necessary to perform the sensitivity measurement, interrogation pulse pairs with the correct spacing and nominal frequency shall trigger the transponder if the peak power density at the transponder antenna is at least minus 103 dBW/m^2. The threshold sensitivity for a reply efficiency of 70 % at the exterior cabinet connector shall be in accordance with the following paragraphs.

3.2.2.6.1 On Channel Sensitivity. For interrogation signals having a repetition rate of 30 pps and having spacings of the constituent pulses of a pair anywhere within the limits of 3.2.2.2, the receiver sensitivity in the absence of other interrogations, and with a dead time setting of 60 μs, shall be –94 dBm or better (i.e., the receiver threshold triggering level shall be –94 dBm or lower). This value shall apply when the receiver gain control is set to allow the maximum permissible number of receiver decodes. Once set within its range, sensitivity must be stable within ±1.0 dB (±2.0 dB over the service range of temperature).

3.2.2.6.1.1 Sensitivity Variation with Interrogation Loading. The transponder sensitivity level shall not vary by more than 1 dB for transponder loading between 0 and 90 % of its maximum transmission rate.

3.2.2.6.1.2 Sensitivity at Other Pulse Spacing. When the spacing of an interrogator pulse pair varies from the nominal value by ±0.5 μs, the receiver sensitivity shall not be reduced by more than 1 dB. The threshold sensitivity to DME signal pulses having a spacing of the constituent pulse of a pair deviating from the nominal value by ±3.0 μs and more shall be reduced by not less than 70 dB.

3.2.2.6.1.3 Desensitization by Adjacent Channel Interrogation. The presence of interrogation signals at ±900 kHz from the on-channel frequency which have pulse coding corresponding to that for the on-channel frequency and which occur at rates up to 1000 pulse pairs per second shall not reduce the on-channel threshold sensitivity by more than 1 dB. The requirement shall be met when the adjacent channel signals have levels up to –10dBm.

3.2.2.6.1.4 Desensitization by Continuous Wave (CW). The presence of CW interference signal on the assigned channel frequency or elsewhere within the receiver pass-band shall not reduce the on-channel threshold sensitivity by more then 2 dB when the level of the CW is 10 dB and more below the on-channel sensitivity level in the absence of CW interference. (This requirement shall be met for all settings of the receiver transmission rate control which result in receiver noise decodes at a rate of no greater than 10 per second.) Additionally, within the range of the receiver desensitization provided by automatic gain reduction the reply efficiency to a single aircraft interrogation shall not be reduced by more than 10 % when the level of the interrogation signal is 6 dB and more above the level of the interfering CW signal.

3.2.2.6.1.5 Desensitization by High Repetition Rate/High Duty Cycle Pulse Signals. In the presence of an input signal with a pulse width of 8 μs where the pulse rate is 30 percent of the transmitter duty cycle and having a peak level equal to the CW level specified in paragraph 3.2.2.6.1.4 (i.e., 10 dB below the on-channel threshold triggering level measured in the absence of interference), the maximum reduction in receiver sensitivity and reply efficiency shall not exceed 0.5 dB and 3 percent, respectively.

3.2.2.6.2 Sensitivity to Adjacent Channel Interrogations. Signals ±900 kHz or greater removed from the desired channel nominal frequency and having signal levels up to –10 dBm shall not trigger the transponder.

3.2.2.6.3 Dynamic Range. The performance of the transponder shall be maintained when the power density of the interrogation signal at the transponder antenna has any value between the minimum specified in 3.2.2.6 above up to a maximum of minus 22 dBW/m^2 when installed with an ILS and minus 35 dBW/m^2 when installed for other applications. The equipment shall not be damaged by input pulse signals at the cabinet connector of up to +20 dBm on any frequency within the DME receiver band.

3.2.2.6.4 Noise Generated Pulse Pairs. When the receiver is interrogated at the power densities specified in 3.2.2.6.1 above to produce a transmission rate equal to 90 % of the maximum, the noise generated pulse pairs shall not exceed 5 % of the maximum transmission rate.

3.2.2.7 Reply Efficiency. The transponder reply efficiency shall be at least 70 % at all values of transponder loading up to the loading corresponding to ICAO Annex 10, Attachment C to Part I, paragraph 7.1.5 and at the minimum sensitivity level specified in 3.2.2.6.1 and 3.2.2.6.1.1 above. When considering the transponder reply efficiency, the DME dead time and loading introduced by monitoring function should be taken into account.

3.2.2.8 Interference Suppression. Signals arriving at the intermediate frequency shall be suppressed at least 80 dB. All other spurious response or signals within the 960 MHz to 1215 MHz band and image frequencies shall be suppressed at least 75 dB.

3.2.2.9 Random Squitter Pulses. The transmitter shall operate at a transmission rate, including randomly distributed pulse pairs and distance reply pulse pairs, of not less than 700 pulse pairs per second except during identity. In the absence of valid interrogations, the minimum transmission rate due to randomly distributed pulse pairs shall not be less than 700 ppps and shall not exceed 850 ppps.

Note: The minimum transmission rate should be as close as practicable to 700 ppps.

3.2.2.9.1 Effect of Traffic Loading. For all interrogation rates resulting in zero to 850 receiver decodes per second, the squitter pulse generator shall produce not more than 850 - N pulses per second nor less than 700 - N pulses per second, where N is the number of receiver decodes. For all interrogation rates resulting in excess of 850 receiver decodes per second, the squitter pulse generator shall produce no output.

3.2.2.10 Automatic Gain Reduction (AGR). When transponder loading exceeds 90 % of the maximum transmission rate, the receiver sensitivity shall be automatically reduced in order to limit the transponder replies, so as to ensure that the maximum permissible transmission rate is not exceeded. The available range of sensitivity reduction shall be at least 50 dB.

3.2.2.11 Priority of Transmission. The transmission of transponder output signal pulses shall conform to the following order of precedence:

(1) Identity pulse groups;
(2) Distance reply pulse pairs; and
(3) Squitter pulse pairs.

Neither distance reply nor squitter pulse pairs shall be transmitted during the transmission of the identification signal pulse groups. Whenever triggers due to squitters occur prior to triggers due to decoded valid interrogations at the input of the priority gating circuits, the squitter triggers shall be inhibited for all spacings between triggers, of 25 μs and less in "X" channel and 10 μs and less in "Y" channel. The above operation applies for reply delay settings of 50 μs and greater. Whenever triggers due to decodes occur prior to squitter triggers, the squitter triggers will be inhibited for all spacings of 25 μs and less for "X" channel and 65 μs and less for "Y" channel.

3.2.3 Identification Signals and Keying. The transponder shall be capable of transmitting an identification signal in both of the following forms below:

a. an "independent" identification consisting of coded (International Morse Code) identity pulses that can be used with all transponders;
b. an "associated" signal that can be used for transponders specifically associated with a VHF navigation system which itself transmits an identification signal.

Both systems of identification shall use signals, which shall consist of the transmission for an appropriate period of a series of paired pulses transmitted at a repetition rate of 1350 ppps and shall temporarily replace all reply pulses that would normally occur at that time. These pulses shall have similar characteristics to the other pulses of the reply signals. Reply pulses shall be transmitted between key down times.

3.2.3.1 Identification Keying Control. When normal identification keying is enabled, the transponder shall transmit identification signals (International Morse Code) when keyed by either the Very High Frequency (VHF) facility or the internal identification keyer to output an identification signal. The DME keyer shall key at 30 ±1 second intervals.

3.2.3.2 Identity Keying Control. A control shall be provided on each transponder to enable (1) normal identification keying, (2) removal of identification keying, and (3) continuous transmission of identification signal pulse groups. As a minimum this control must be local to the system.

3.2.3.3 Independent Identification Signal Characteristics.

a. The identity signal shall consist of the transmission of the beacon code in the form of dots and dashes (International Morse Code) of identity pulses at least once every 30 seconds, at a rate of at least 6 words per minute; and

b. The identification code characteristic and letter rate for the DME transponder shall conform to the following to ensure that the maximum total key down time does not exceed five (5) seconds per identification code group. The dots shall be a time duration of 0.1 second to 0.160

second. The dashes shall be typically three (3) times the duration of the dots. The duration between dots and/or dashes shall be equal to that of one dot plus or minus 10 percent. The time duration between letters or numerals shall not be less than three dots. The total period for transmission of an identification code group shall not exceed 10 seconds.

3.2.3.4 Associated Identification Signal Characteristics.

a. When associated with a VHF facility, the identification shall be transmitted in the form of dots and dashes (International Morse Code) as in 3.2.3.3 above and shall be synchronized with the VHF facility identification code;
b. The DME transponder shall be capable of transmitting the transponder identification when keyed by the DME keying output of the associated VHF facility.

Note: The typical implementation is that each 30-second interval is divided into four or more equal periods by the associated VHF facility where the intent is the DME transmits the transponder identification during one period and the VHF facility transmits the facility identification during the remaining periods.

3.2.4 Transmitter and Associated Circuitry.

3.2.4.1 Tuning and Spurious Output.

a. The tuning of all RF stages shall be straightforward and free of ambiguities. Spurious output or parasitic oscillations shall be at least 40 dB below the associated reference signal in any stage for any combination of tuning control positions with either normal or subnormal excitation conditions. The associated reference signal refers to the signal used to accomplish the tuning / adjustment function.
b. To ensure hazardous or misleading information (HMI) is not radiated by the antenna, spurious output or parasitic oscillations shall be no more than –100 dBm as measured at the coaxial cable connector that provides the feed to the antenna.

3.2.4.2 RF Output Power Control. Means shall be provided to permit continuous adjustment of the RF output power in 0.25 dB steps from a preset level of 1000 watts or a preset level of 100 watts over the range of 0 to –4 dB respectively. All transponder output signal requirements shall be met throughout the range of power output levels without the need for readjustment of any other controls.

3.2.4.3 Reply Delay Values and Adjustments. The standard values of reply delay are 50 μs for X channel and 56 μs for Y channel. Controls shall be provided to set the nominal reply delay time within 0.0625 μs of any desired value between the limits of 35 to 56 μs on "X" channels, or 50 to 62 μs on "Y" channels.

3.2.4.4 Accuracy. The transponder shall not contribute more than plus or minus 0.5 μs (75 meter (250 feet)) to the overall system error budget.

3.2.5 Power Delay Control and Adjustment.

3.2.5.1 Local High Voltage Control. A manual means of applying high voltage to the transmitter when the unit is in local control shall be located on the front surface of the transponder. A "High Voltage" indicator shall be located on the front surface of the transponder in a prominent and visible location.

3.2.6 Transponder Output Signals.

3.2.6.1 Pulse Shape. The RF envelope of each pulse shall meet the following requirements when measured using a linear detector.

3.2.6.1.1 Rise Time. Pulse rise time shall be 2.5 (+0.5, -1.0) μs.

3.2.6.1.2 Pulse Top. The instantaneous amplitude of the pulse shall not, at any instant between the point of the leading edge which is 95 % of maximum amplitude and the point of the trailing edge which is 95 % of the maximum amplitude, fall below a value which is 95 % of the maximum voltage amplitude of the pulse.

3.2.6.1.3 Pulse Duration. Pulse duration shall be 3.5 (±0.5)μs.

3.2.6.1.4 Decay Time. Pulse decay time shall nominally be 2.5 μs but shall not exceed 3.0 μs nor be less than 1.5 μs.

3.2.6.1.5 Instantaneous Magnitude. To ensure proper operation of the thresholding techniques, the instantaneous magnitude of any pulse turn-on transients, which occur in time prior to the virtual origin, shall be less than one percent of the pulse peak amplitude. Initiation of the turn-on process shall not commence sooner than 1 μs prior to the virtual origin.

3.2.6.2 Pulse Coding. Pulses shall be coded in pairs with a spacing, as measured between the 50 percent maximum voltage amplitude point on the leading edge of the first RF pulse to the corresponding point on the leading edge of the second RF pulse, of (a) 12 (±0.25) μs for "X" channels or, (b) 30 (±0.25) μs for "Y" channels.

3.2.6.3 RF Delay Time Variation. Reply delay time variation shall not exceed the following:

a. ±0.5 μs over the range of service conditions with an input signal level having any value between –94 dBm and –79 dBm with an interrogation pulse rise time of 2.5 (±0.5) μs;

b. ±0.10 μs over the range of service conditions with an input signal level having any value between –79 dBm and –10 dBm with an interrogation pulse rise time of 0.10 (±0.10) μs;

c. A total variation of 0.10 μs with an input signal level of –60 dBm with a variation of interrogation pulse rise time through the range of 0.20 to 0.80 μs and a total variation of 0.5 μs through the range of 0.80 to 3.0 μs;

d. A total variation of 0.10 μs with an input signal level of –60 dBm with a variation in interrogation pulse rate frequency (PRF) from 2500 through the maximum transmission rate with an interrogation pulse rise time of 0.10 (±0.10) μs.

3.2.6.4 Transponder Power Output. The transponder shall be able to be set such that the output power can be one of two preset levels. These preset levels shall be 100 watts and 1000 watts. The preset levels shall be attained with minimal modification within 30 minutes without special tools needed for the DME system. The power output at the peak of each pulse shall not be less than the preset levels of 100 watts (i.e., a Low Power DME) or 1000 watts (i.e., a High Power DME) as measured at the output of the equipment cabinet.

3.2.6.5 Pulse Power Variation. The peak power of the constituent pulses of any pair of pulses shall not differ by more than 1 dB. Additional amplitude modulation of the output pulse train shall not exceed 5 percent.

3.2.6.6 RF Pulse Signal Spectrum. The spectrum of the pulse modulated signal shall be such that during the pulse the effective radiated power contained in a 0.5 MHz band centered on frequencies 0.8 MHz above and 0.8 MHz below the nominal channel frequency in each case shall not exceed 200 mW, and the effective radiated power contained in a 0.5 MHz band centered on frequencies 2 MHz above and 2 MHz below the nominal channel frequency in each case shall not exceed 2 mW. The effective radiated power contained within any 0.5 MHz band shall decrease monotonically as the band center frequency moves away from the nominal channel frequency.

Note: Guidance material relating to the pulse spectrum measurement is provided in ICAO Annex 10, Attachment C, section 7.1.11.

3.2.6.7 Out-of-Band Spurious Radiation. At all frequencies from 10 to 1800 MHz, but excluding the band of frequencies from 960 to 1215 MHz, the spurious output of the DME transponder transmitter shall not exceed minus 40 dBm in any one kHz of receiver bandwidth. The equivalent isotropically radiated power of any CW harmonic of the carrier frequency on any DME operating channel shall not exceed minus 10 dBm.

3.2.6.7.1 Voltage Standing Wave Ratio (VSWR) Protection. The transmitter shall be protected from damage due to high VSWR on the antenna connection. Protection shall be provided for both open and short conditions.

3.2.6.8 Inter-pulse Output Level. The RF output level during the interval between occurrences of the desired pulse pairs shall not exceed a level that is 80 dB below the maximum power level during the pulse. In addition, between the pulses of each pair there shall be an interval of 1.0 μs or greater length during which the RF output level does not exceed a level that is 80 dB below the maximum power level of each pulse.

3.2.6.9 Retriggering of Transponder. The transponder shall include a decoding circuit such that the transponder can be triggered only by pairs of received pulses having pulse duration and pulse spacings appropriate to interrogator signals as described in paragraph 6.1.1.

3.2.6.10 Equivalent Isotropically Radiated Power (EIRP). The peak equivalent isotropically radiated power shall not be less than that required to ensure a peak pulse power density of minus 89 dBW/m^2 under all operational weather conditions at any point within the coverage volume.

3.2.7 Stabilization of Performance Characteristics. After power has been applied to the transponder for not more than five (5) minutes in standby mode, upon transfer to operational mode the transmitter shall result in a fully compliant operational system within three (3) seconds.

3.2.8 Duty Cycle Overload Protection. A means shall be provided to protect the equipment components against the effect of excessively high transponder output pulse rates caused by malfunction of squitter, identification, or receiver AGR circuits.

3.2.9 Thermal Overload Protection. A means shall be provided to protect the equipment against operating above its thermal design limits.

3.3 Antenna Requirements.

3.3.1 Antenna Type. Antenna can be uni-directional, bi-directional, or omni-directional but must meet the range and coverage requirements as given in paragraph 3.1.10 of this document and the transponder shall be capable of operating with only one antenna.

3.3.2 Frequency Range. The antenna shall fill all requirements through the frequency band of 960 MHz to 1215 MHz without tuning or adjustment.

3.3.3 Polarization. The predominant energy radiated by the antenna shall be vertically polarized.

3.3.4 Characteristic Impedance and VSWR. The antenna unit shall have a characteristic impedance of 50 ohms. The VSWR, as measured at the end of a low loss cable not exceeding five (5) feet in length shall not be greater than: 2:1 for an omni-directional and bi-directional antenna; or 2.5:1 for a uni-directional antenna, throughout the specified range of frequencies.

3.3.5 Antenna Gain. The antenna shall meet the following gain requirements:

a. Omni-directional antenna: The gain at the maximum power point of the vertical pattern shall not be less than 8.0 dBi at all azimuths;
b. Directional antennas: The gain at the maximum power point of the vertical pattern shall be at least 8.0 dBi at all azimuths within the 3dB beam width(s).

3.3.6 Vertical Pattern. The radiation pattern of the antenna in the vertical plane:

1. Shall have a lobe of energy not less than 5 degrees wide at the half-power points, -3 dB (0.707 Volts);
2. Shall have the vertical angle of maximum radiated energy between 2.0 degrees and 5.0 degrees above the horizon;
3. Shall have a relative gain on the horizon not less than -6 dB (0.5 Volts);
4. Shall have the signal intensity of the radiated energy at an elevation angle of 1 degree above the horizon at least 0.20 Volts per meter above the signal intensity of the radiated energy at an elevation angle of 1.0 degree below the horizon where the intensity is normalized to the value at the horizon;
5. Shall have relative gain at angles between 6 and 50 degrees below the horizon lower than the relative gain at the peak of the major lobe above the horizon by at least 8 dB (0.4 Volts);
6. Shall have relative gain at angles between 6 and 15 degrees above the horizon greater than a level that is 20 dB (0.1 Volts) below relative gain at the peak of the major lobe above the horizon;
7. Shall have relative gain at angles between 15 and 45 degrees above the horizon greater than a level that is 30 dB (0.032 Volts) below relative gain at the peak of the major lobe above the horizon.

Note: These requirements are illustrated in Figure 6, which is given in normalized voltage vs. angle. Each requirement is given in dB with normalized voltage in parentheses and corresponds to the appropriate number in the figure.

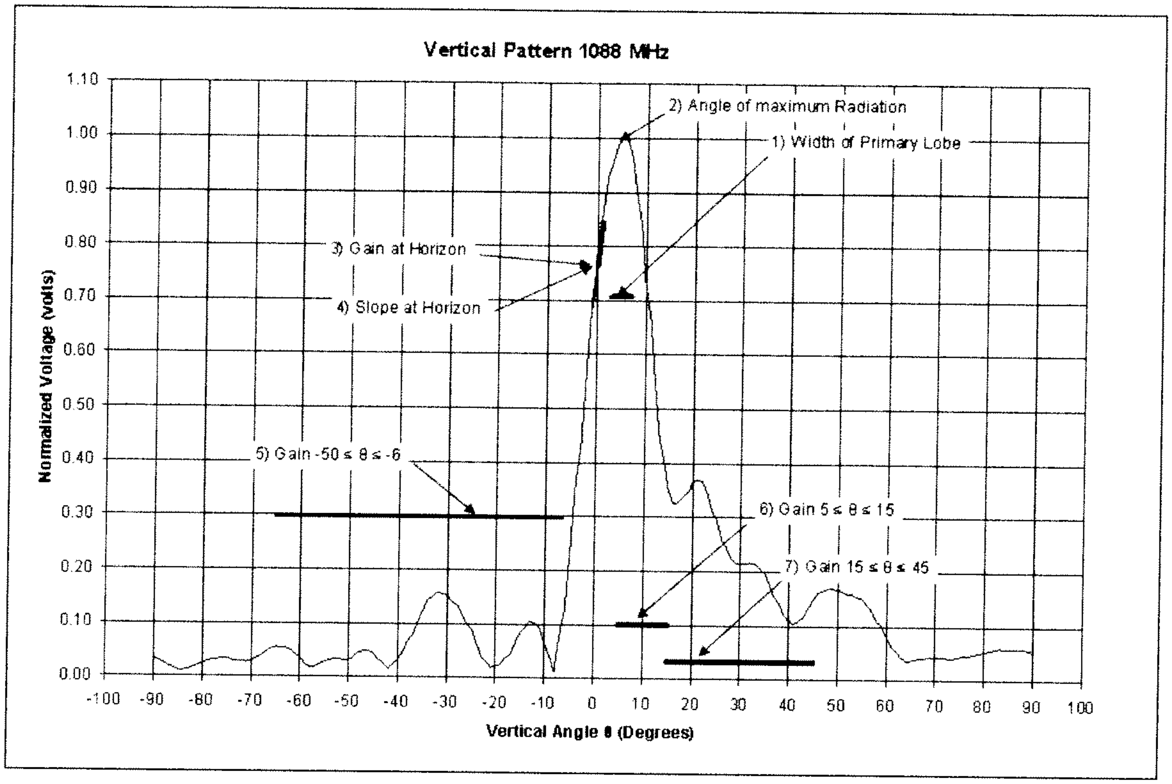

Figure 6. Example of a Vertical Field Pattern for a DME Antenna

3.3.7 Horizontal Pattern. The horizontal pattern for the antenna shall meet the requirements as needed for the coverage volumes defined in paragraph 3.1.10. The preset power level of 1000 Watts will primarily be used for the omni-directional coverage areas as defined in paragraph 3.1.10. The preset power level of 100 Watts will be used for omni and directional coverage areas.

3.3.8 Radome and Weatherproofing. The radome shall be smooth and shall minimize wind loading and the accumulation of water, snow, and ice. The entire antenna assembly including cable connectors shall be effectively sealed (weatherproofed) to prevent the entrance of foreign matter in such a manner as to permit removal and replacement of the radome without the necessity of sealing compounds.

3.3.9 Antenna Mount. The configuration of the antenna base shall be such that the antenna may be mounted directly, or indirectly, through use of an adaptor furnished with each antenna, to a standard 4 inch steel pipe (nominal outside diameter of four (4) inches). The mounting fixture shall engage not less than six (6) inches of the pipe and shall be provided with clamping screws and locknuts for securing the fixture to the pipe. The design shall provide unobstructed access to all connectors.

3.3.10 Vibration, Wind, and Ice Loading. The antenna and its mounting fixture shall be capable of withstanding without damage: (a) sustained vibration at the resonant frequencies of the assembly for a continuous period of not less than 125 million cycles, and (b) wind loading in gusts at velocities of not less than 100 miles per hour. The contractor may demonstrate compliance with requirement (a) above by means of design calculations and limited vibration testing to determine the resonant frequencies of the assembly. When design calculations are used, the calculations shall be based on the properties and characteristics of the materials as used. Compliance with the requirements of (b) above may be demonstrated by static loading in lieu of wind testing. The antenna shall operate with up to ½ inch accumulation of clear ice on all outdoor components.

3.3.11 Monitor Probes. Two coupling probes, for monitoring the signal radiated by the antenna, shall be provided within the antenna radome and separately terminated in 50 ohm resistance loads at capped weather proofed coaxial connectors at the base of the antenna. The RF coupling factor for each probe shall be as required to achieve monitoring in accordance with paragraph 3.4.4.2 (output power) and shall not vary from the design center values by more than 0.5 dB throughout the range of ambient conditions specified in paragraph 3.1.17 Outdoors. Additionally, the difference in output level between probes shall not exceed 2 dB.

3.3.12 Antenna Cables. The cable used to connect the DME antenna to the DME system shall have characteristics such that an impedance of 50 Ohms is present and a signal loss of no more than 3dB/100ft is attained for the frequency range of 960 MHz to 1215 MHz.

3.3.13 Obstruction Lights. A dual lamp obstruction light fixture with red cover globes shall be provided on the DME antenna radome. This dual Light-Emitting Diode (LED) obstruction light assembly shall be in accordance with FAA Advisory Circular AC150/5345-43.

3.3.14 Power Handling. The antenna used for a DME system shall be capable of handling DME signals with an instantaneous output power up to 2000 watts and an average power of 80 watts (4 % duty cycle).

3.4 Monitor. The monitor shall be failsafe. Failure of any part of the monitor itself shall automatically produce the same results as the malfunctioning of the element being monitored.

3.4.1 Operating Channels. Monitors shall provide the specified performance appropriate to the assigned DME channel. DME operating channels characteristics are described in ICAO Annex 10, Chapter 3, Table A (or FAA Order 6050.32, Appendix 3, Section I); i.e., 252 channels in which the channel numbers, frequencies, and pulse codes are assigned.

3.4.1.1 Frequency and Accuracy Stability. For each output frequency required from the signal generator the frequency of operation shall not vary more than plus or minus 0.001 percent from the assigned frequency.

3.4.2 Monitor RF Input/Output Signal Coupling. The monitoring of radiated power shall be accomplished through the sampling of RF signals from the monitor probes of the antenna. The power monitoring detector shall be within the monitor equipment.

3.4.3 Interrogation Signal Generator. The interrogation signal generator shall provide interrogation and timing reference signals for the relevant functions of the transponder monitor and, when used with test equipment, shall provide the capability for determining and maintaining the performance of the transponder in response to interrogation signals.

3.4.3.1 Operational Modes. In the normal mode of operation, when functioning as part of the executive monitor, the interrogation signal generator shall provide on-channel frequency RF pulse pairs at fixed levels, spacing, and interrogation rate for the monitoring of the reply delay and receiver sensitivity parameters. The signal generator shall also provide the capability of interrogating at off-channel frequencies, alternate RF levels, pulse spacings, and interrogation rates for the measurement and certification of other specific performance characteristics of the transponder.

3.4.3.2 Pulse Synchronization Output. The interrogation signal generator shall provide an output pulse that can be utilized for purposes of triggering test equipment or providing accurate pulse timing. This output pulse shall be easily accessible. This output pulse will operate for all interrogation signal pulse rates from 10 to 10,000 pulse pairs per second.

3.4.3.3 RF Output Pulse Signal.

3.4.3.3.1 Rise Time. - The rise time shall be 2.5 (±0.5) μs.

3.4.3.3.2 Pulse Top. The instantaneous amplitude of the pulse shall not, at any instant between the point of the leading edge which is 95 % of maximum amplitude and the point of the trailing edge which is 95 % of the maximum amplitude, fall below a value which is 95 % of the maximum voltage amplitude of the pulse.

3.4.3.3.3 Pulse Duration. The pulse duration shall be 3.5 (±0.5) μs.

3.4.3.3.4 Decay Time. The decay time shall be 2.5 (+0.5, -1.0) μs.

3.4.3.4 Pulse Coding. Pulses shall be coded in pairs with a spacing, as measured between the 50 percent maximum voltage amplitude point on the leading edge of the first RF pulse to the corresponding point on the leading edge of the second RF pulse, of (a) 12 (±0.2) μs for "X" channels or, (b) 36 (±0.2) μs for "Y" channels.

3.4.3.5 Pulse Power Variation. The peak power of the constituent pulses of any pair of pulses shall not differ by more than 0.5 dB.

3.4.3.6 Detected RF Output Signal. To provide for determination of pulse characteristics and for timing measurements a video waveform corresponding in shape and time to the envelope of each RF pulse shall be provided for display.

3.4.3.7 RF Pulse Spectrum. At least 90 percent of the output signal RF energy shall be contained within a 0.5 MHz band centered on the interrogation frequency in use. The remaining energy shall be essentially equally distributed on both sides of the 0.5 MHz band centered on the interrogation frequency and shall diminish in level at frequencies further removed from the channel frequency.

Note. Guidance material relating to the pulse spectrum measurement is provided in ICAO Annex 10, Attachment C, section 7.1.11

3.4.3.8 Spurious Output. Out-of-band spurious radiation. At all frequencies from 10 to 1800 MHz, but excluding the band of frequencies from 1039 to 1085 MHz, the spurious output of the signal generator shall not exceed minus 40 dBm in any one kHz of receiver bandwidth. In addition the power at the RF output connector during the intervals between occurrences of the desired interrogation pulse pairs shall not exceed a level of −80 dBm for all settings of the output attenuator.

3.4.3.9 Test RF Output Frequency. The signal generator shall, when commanded, provide RF output at the channel interrogation frequency, at ±200kHz, and at ±900 kHz with respect to the nominal interrogation frequency in use. All signal generator performance requirements shall be met without retuning or readjustment of any controls when each of the output frequencies referenced herein are selected. The RF output at ±200 kHz and ±900 kHz shall be within 0.5 dB of the RF output at the nominal interrogation frequency.

3.4.3.10 RF Output Level Calibration. A means shall be incorporated for setting the RF power to a reference calibration level. The RF power shall be automatically maintained at the calibration level under all conditions of pulsed operation.

3.4.3.11 RF Output Level And Accuracy. The RF output level shall be continuously variable between the limits of -10 dBm and −100 dBm as measured in a 50-ohm resistance load at the transponder receiver input. The output attenuator shall be essentially linear with a control resolution of ≤ 1dB over the specified range and the output level shall be within 1.0 dB of the indicated level.

3.4.4 Transponder Monitor.

3.4.4.1 Monitor Alarm Action. The monitor shall provide two separate output alarm actions for purposes of automatic control and remote monitoring of the DME, one designated "primary parameter alarm" and the other designated "secondary parameter alarm." Both types of actions are described below. The reply delay parameter is always set as a primary alarm.

Primary Alarm: In the event that any of the monitored parameters set to a primary alarm action produce an out of tolerance condition, the monitor will cause the following action to take place:

a. a positive indication of the alarm condition shall be given at a control point;
b. the operating transponder shall be automatically switched off;
c. the standby transponder, if provided, shall be automatically switched into operation;
d. in the event that any out of tolerance conditions occur for the standby transponder, a positive indication of the alarm condition shall be given at a control point; and
e. the standby transponder shall be automatically switched off.

Secondary Alarm: In the event that any of the monitored parameters set to a secondary alarm action produce an out-of-tolerance condition, the monitor will cause the following action to take place:

a. a positive indication of the warning shall be given at a control point;
b. if a standby transponder is available, automatic switching shall attempt to ensure continuous service with the best available transponder, including operation under a warning condition; and,
c. the automatic switching logic shall be the same as for primary alarms.

3.4.4.1.1 Alarm Delay Time. The delay between the occurrence of a faulty condition and the execution of monitor control actions and fault annunciation shall not exceed 10 seconds, except for identification. This delay should be as low as practicable, taking into consideration the need to avoid interruption of transponder service due to transient effects. For absence of identification, the delay between the occurrence of a faulty condition and monitor action shall not exceed 45 (+5, -0) seconds.

3.4.4.1.2 Monitor Response Time. The following requirement shall be met under conditions in which all faults have been sensed for a continuous period of 10 seconds, or longer. Within three (3) seconds after the application of transponder output signals, which have characteristics that are all within a range prescribed for non-fault conditions, all sensed faults and alarm indication shall end.

3.4.4.2 Monitored Parameter Fault Thresholds.

3.4.4.2.1 Required Parameters. These parameters are required to be monitored and can be set to primary or secondary alarms. The reply delay parameter is always set to primary alarm. The monitor shall cause the actions described in paragraph 3.4.4.1 if:

a. The reply efficiency, at the minimum receiver sensitivity established from 3.2.2.6, is less than 70 %;

b. The transponder reply delay differs from the assigned value by 0.5 μs (75 meter (250 feet)) or more (Must be set as primary alarm);
c. The spacing between the first and second pulses of the transponder reply pulse pair differs from the assigned value by 0.5 μs (75 meter (250 feet)) or more;
d. The transmission rate is less than the rate required for compliance with the specification in 3.2.2.10;
e. A reduction in the radiated power of 3 dB and greater, or tolerance established by flight inspection;
f. A reduction in the output power of 3 dB and greater;
g. Absence of, incorrect, or continuous identification;
h. Transponder receiver and transmitter frequencies that vary by more than the requirement in paragraph 3.2.1.1 from the assigned frequency.

3.4.4.3 Test Signals and Monitoring Activities. The transponder shall not be triggered more than 120 times per second for either monitoring or automatic frequency control purposes, or both.

3.5 Control / Status / Indicator Functions.

3.5.1 Control Functions. The DME will have the following control functions as a minimum available in a local environment, remote environment, or both. The following paragraphs describe what each environment requires as a minimum for control functions.

3.5.1.1 Local/Remote Control Functions. The following control functions will be provided as a minimum in the local control environment and the remote control environment:
a. Shall provide for local and remote control of the DME;
b. Shall provide for automatic shutdown of the transponder in response to the alarms sensed by the monitor equipment;
c. Shall provide a mode of operation in which only the monitor shutdown action is inhibited with appropriate indication as required in paragraph 3.5.3;
d. Set/reset the DME to a known state.

3.5.1.2 Local Control Functions. The following control functions will be provided as a minimum in the local control environment. A manual operation (button, switch, etc.) shall be provided so as to be easily accessible from the front of the DME to select from local or remote control. This operation shall take precedence over any current remote control so that only local control is enabled.

3.5.1.3 Remote Control Functions. The following control functions will be provided as a minimum in the remote control environment.

a. Shall respond to all control operations with a command acknowledgment and an indication of either successful command execution or command failure, including communication faults;
b. Shall enforce pre-established user access control rules when performing a control operation;
c. Shall be able to adjust fault thresholds;
d. Shall be able to adjust parameters that determine automatic fault isolation and fault recovery processing;
e. Shall perform diagnostics to detect and/or isolate faults;
f. Shall be able to configure the automatic reset function specified in paragraph 3.5.1.4;
g. Shall be able to perform a monitor integrity test (MIT) on the transponder monitor.

3.5.1.4 Automatic Reset Function. The automatic reset function shall be inherent to the DME equipment and provide the following:

a. Shall provide for automatic reset and restart of the equipment subsequent to shutdown due to an alarm action;
b. Shall be configurable through the remote environment;
c. Shall be configurable to provide up to three user-defined reset/restart time intervals.

3.5.2 Status Functions. The DME will have the following status functions as a minimum available in a local environment, remote environment, or both. The following paragraphs describe what each environment requires as a minimum for status functions.

3.5.2.1 Local/Remote Status Functions. The following status functions will be provided as a minimum in the local status environment and the remote status environment.

a. Shall determine and report the operating status of each DME subsystem;
b. Shall monitor the primary and backup equipment of each DME;
a. Shall perform monitoring without interfering with the operation of the DME;
b. Shall perform monitoring automatically without the need for user intervention;
c. Shall determine and report the logical and physical configuration of the DME elements to the extent that is practical;
d. Shall determine and report the availability status of DME elements;
e. Shall report changes in the fault, configuration, performance, or security status of the system.

3.5.2.2 Local Status Functions. There are no status functions that are required as a minimum in the local status environment only. Those listed in paragraph 3.5.2.1 as being required for both the local and remote environments are required.

3.5.2.3 <u>Remote Status Functions.</u> The following status functions will be provided as a minimum in the remote status environment.

a. Shall determine and report the status of the DME environment (e.g., smoke, fire, or temperature attributes);
b. Shall determine and report system resource utilization;
c. Shall report all users logged onto the monitored system automatically;
d. Shall provide a summary alarm for all major components, which reports the failure or imminent failure of the system. This may be a roll up of selected alarms when said alarms taken separately may not endanger the system integrity but when taken together, result in a loss of service or imminent loss of service;
e. Shall provide the capability to configure the system so alarms are not generated or distributed from the Remote Monitoring System (RMS) when the system is commanded off or when a system is off as a normal state.

3.5.3 <u>Indicator Functions.</u> The DME will have the following indicator functions as a minimum available in a local environment, remote environment, or both. The following paragraphs describe what each environment requires as a minimum for indicator functions.

3.5.3.1 <u>Local/Remote Indicator Functions.</u> The following indicator functions will be provided as a minimum in the local indicator environment and the remote indicator environment:

a. Shall provide for local and remote indication of the monitor alarm condition;
b. Shall provide for local and remote indication of the mode of operation defined in paragraph 3.5.1.1 item c;
c. Shall provide for indication of the system operating on battery power;
d. Shall provide for indication of AC power failure.

3.5.3.2 <u>Local Indicator Functions.</u> The following control functions will be provided as a minimum in the local indicator environment:

a. A visual status indicator shall be located on the front of the equipment and shall provide a positive indication whenever an alarm condition exists. The following colors shall be used for indicators: Green normal operation, Amber/Yellow alert condition, and Red alarm condition.
b. An aural alarm shall provide indication in response to an alarm condition. A manual operation (button, switch, etc.) shall be provided to permit silencing of the aural alarm. This manual operation shall be accessible from the front panel of the DME.

3.5.3.3 Remote Indicator Functions. There are no indicator functions that are required as a minimum in the local indicator environment only. Those listed in paragraph 3.5.3.1 as being required for both the local and remote environments are required.

3.6 Remote Monitoring System. The DME shall have embedded RMM capability that meets the requirements defined for the remote environments of paragraph 3.5 and the additional requirements below.

3.6.1 Additional Requirements. The DME will provide the capability to meet the following criteria:

a. System parameters shall be grouped for retrieval (i.e., certification parameters, key performance parameters, fault diagnostic parameters, etc.);
b. Shall provide diagnostics and system verification;
c. Shall provide the ability to quickly access required data;
d. Shall perform automatic self-tests (i.e., diagnostics, loop-back tests, etc.) without interfering with the operation of the DME;
e. In the event of a restart/reboot (i.e., a momentary loss of power), the DME software shall automatically reinitiate itself and be fully functional with the latest loaded software version;
f. Shall provide the capability to perform trend analysis on the DME system parameters defined in paragraph 3.4.4.2.1.

3.7 First Article. When specified, a sample shall be subjected to first article inspection in accordance with 4.2.2.

4.0 VERIFICATION

4.1 Classification of Inspections. The inspection requirements specified herein are classified as follows:

a. Design qualification inspection (see 4.2.1);
b. First article inspection (see 4.2.2);
c. Conformance inspection (see 4.2.3).

4.2 Description of Inspections.

4.2.1 Design Qualification Inspection. The design qualification inspection will be conducted to examine the design of the system and test for all functional requirements. Design qualification inspection shall include all test procedures in section 4.5 in the verification section of this document.

4.2.2 First Article Inspection. First article inspection shall be performed on one complete DME system when a first article sample is required (see 3.7). First article inspection shall include the procedures of 4.5.2 and 4.5.4 in the verification section of this document.

4.2.3 Conformance Inspection. Conformance inspection shall include the procedures of 4.5.2 and 4.5.4 in the verification section of this document.

4.3 Verification Requirements Traceability Matrix (VRTM).

Legend:
Design Quality Test (DQT)
Production Acceptance Test (PAT)
Type Test (TT)
A – Analysis
D – Demonstration
I – Inspection
T – Test.

Table 1. Verification Requirements Traceability Matrix

Specification		**Test Level and Method**			**Verification**
Paragraph Number	Parameter Name	DQT	PAT	TT	Paragraph
3.1	**General Requirements**				
3.1.1	Modular Construction	I			4.5.1.1
3.1.2	Primary Power Source	I			4.5.1.2
3.1.3	Solid State Design	I			4.5.1.3
3.1.4	Test Points and Connectors	I			4.5.1.4
3.1.5	Interlock Signal from ILS	T			4.5.1.5
3.1.6	Battery Backup	T			4.5.1.6
3.1.7	Equipment Cabinet	I			4.5.1.7
3.1.8	DME Purpose	D			4.5.1.8
3.1.9	Range	A			4.5.1.9
3.1.10	Coverage	A			4.5.1.10
3.1.11	Accuracy	A			4.5.1.11
3.1.11.1	System Accuracy	T		T	4.5.1.11.1
3.1.11.2	DME Accuracy	T		T	4.5.1.11.2
3.1.11.3	Transponder Capacity	A			4.5.1.11.3
3.1.12	Maintainability	D			4.5.1.12
3.1.13	Reliability	A/D			4.5.1.13
3.1.14	Continuity of Service	A			4.5.1.14
3.1.15	Integrity of Signal	A			4.5.1.15
3.1.16	Security Requirements	D			4.5.1.16
3.1.16.1	Data Security	D			4.5.1.16
3.1.17	Operational Environmental Conditions	T			4.5.1.17
3.1.18	Electromagnetic Interference (EMI)	A			4.5.1.18
3.1.18.1	Electromagnetic Compatibility (EMC)	A			4.5.1.18.1
3.1.19	Operation of Overload Protective Devices	D			4.5.1.19
3.1.20	Static Discharge	D			4.5.1.20
3.1.21	Grounding and Bonding	D			4.5.1.21

Specification		Test Level and Method			Verification
Paragraph Number	Parameter Name	DQT	PAT	TT	Paragraph
3.2	**Transponder Requirements**				
3.2.1	Operating Channels	T	T	T	4.5.2.1
3.2.1.1	Channel Frequency and Stability	T	T	T	4.5.2.1.1
3.2.2	Receiver and Video Circuitry	T	T	T	4.5.2.2
3.2.2.1	Receiver Bandwidth and Stability	T	T	T	4.5.2.2.1
3.2.2.1.1	Receiver Bandwidth	T	T	T	4.5.2.2.1.1
3.2.2.2	Receiver Decoder	T	T	T	4.5.2.2.2
3.2.2.2.1	Decoding Circuit Performance	T	T	T	4.5.2.2.2.1
3.2.2.2.2	Decoder Rejection Pulse Spacing	T	T	T	4.5.2.2.2.2
3.2.2.2.3	Decoder Rejection Pulse Width	T	T	T	4.5.2.2.2.3
3.2.2.3	Receiver Dead Time	T	T	T	4.5.2.2.3
3.2.2.4	Receiver Recovery Time	T	T	T	4.5.2.2.4
3.2.2.5	**Echo Suppression**				
3.2.2.5.1	Short Distance Echoes	T		T	4.5.2.2.5.1
3.2.2.5.2	Long Distance Echoes	T		T	4.5.2.2.5.2
3.2.2.5.2 a.	Adjustable Trigger Level	T		T	4.5.2.2.5.2
3.2.2.5.2 b.	Receiver Desensitization Pulse	T		T	4.5.2.2.5.2
3.2.2.5.2 c.	Duration Suppression Pulse	T		T	4.5.2.2.5.2
3.2.2.5.2 d.	Degree of Receiver Desensitization	T		T	4.5.2.2.5.2
3.2.2.5.2 e.	Dynamic Range of Receiver Desensitization	T		T	4.5.2.2.5.2
3.2.2.5.2 f.	Suppression Trigger	T		T	4.5.2.2.5.2
3.2.2.5.3	Echo Suppression Disable	T		T	4.5.2.2.5.3
3.2.2.5.4	DME Traffic Load Monitoring	T		T	4.5.2.2.5.4
3.2.2.6	Receiver Sensitivity	T	T	T	4.5.2.2.6
3.2.2.6.1	On Channel Sensitivity	T		T	4.5.2.2.6.1
3.2.2.6.1.1	Sensitivity Variation with Interrogation Loading	T		T	4.5.2.2.6.1.1
3.2.2.6.1.2	Sensitivity at Other Pulse Spacing	T	T	T	4.5.2.2.6.1.2
3.2.2.6.1.3	Desensitization by Adjacent Channel Interrogation	T	T	T	4.5.2.2.6.1.3
3.2.2.6.1.4	Desensitization by CW	T		T	4.5.2.2.6.1.4
3.2.2.6.1.5	Desensitization by High Repetition Rate/High Duty Cycle Pulse Signals	T		T	4.5.2.2.6.1.5
3.2.2.6.2	Sensitivity to Adjacent Channel Interrogations	T	T	T	4.5.2.2.6.2
3.2.2.6.3	Dynamic Range	T		T	4.5.2.2.6.3
3.2.2.6.4	Noise Generated Pulse Pairs	T		T	4.5.2.2.6.4
3.2.2.7	Reply Efficiency	T	T	T	4.5.2.2.7
3.2.2.8	Interference Suppression	T		T	4.5.2.2.8
3.2.2.9	Random Squitter Pulses	T		T	4.5.2.2.9
3.2.2.9.1	Effect of Traffic Loading	T		T	4.5.2.2.9.1
3.2.2.10	Automatic Gain Reduction	T		T	4.5.2.2.10

Specification		Test Level and Method			Verification
Paragraph Number	Parameter Name	DQT	PAT	TT	Paragraph
3.2.2.11	Priority of Transmission	T		T	4.5.2.2.11
3.2.3	Identification Signals and Keying	T		T	4.5.2.3
3.2.3.1	Identification Keying Control	T		T	4.5.2.3.1
3.2.3.2	Identity Keying Control	T		T	4.5.2.3.2
3.2.3.3	Independent Identification Signal Characteristics				
3.2.3.3 a.	Independent Identification Signal Characteristics	T		T	4.5.2.3.3
3.2.3.3 b.	Independent Identification Signal Characteristics	T		T	4.5.2.3.3
3.2.3.4	Associated Identification Signal Characteristics				
3.2.3.4 a.	Associated Identification Signal Characteristics	T		T	4.5.2.3.4
3.2.3.4 b.	Associated Identification Signal Characteristics	T		T	4.5.2.3.4
3.2.4	**Transmitter and Associated Circuitry**				
3.2.4.1	Tuning and Spurious Output				
3.2.4.1 a.	Tuning and Spurious Output	T			4.5.2.4.1
3.2.4.1 b.	Tuning and Spurious Output	T			4.5.2.4.1
3.2.4.2	RF Output Power Control	T		T	4.5.2.4.2
3.2.4.3	Reply Delay Values and Adjustments	T		T	4.5.2.4.3
3.2.4.4	Accuracy	T		T	4.5.2.4.4
3.2.5	Power Delay Control and Adjustment				4.5.2.5
3.2.5.1	Local High Voltage Control	D	D	D	4.5.2.5.1
3.2.6	**Transponder Output Signals**				
3.2.6.1	Pulse Shape	T	T	T	4.5.2.6.1
3.2.6.1.1	Rise Time	T	T	T	4.5.2.6.1.1
3.2.6.1.2	Pulse Top	T	T	T	4.5.2.6.1.2
3.2.6.1.3	Pulse Duration	T	T	T	4.5.2.6.1.3
3.2.6.1.4	Decay Time	T	T	T	4.5.2.6.1.4
3.2.6.1.5	Instantaneous Magnitude	T		T	4.5.2.6.1.5
3.2.6.2	Pulse Coding	T		T	4.5.2.6.2
3.2.6.3	RF Delay Time Variation	T		T	4.5.2.6.3
3.2.6.3 a.	Variation/Specified Conditions	T		T	4.5.2.6.3
3.2.6.3 b.	Variation/Specified Conditions	T		T	4.5.2.6.3
3.2.6.3 c.	Variation/Specified Conditions	T		T	4.5.2.6.3
3.2.6.3 d.	Variation/Specified Conditions	T		T	4.5.2.6.3
3.2.6.4	Transponder Power Output	T	T	T	4.5.2.6.4
3.2.6.5	Pulse Power Variation	T		T	4.5.2.6.5
3.2.6.6	RF Pulse Signal Spectrum	T		T	4.5.2.6.6
3.2.6.7	Out-of-Band Spurious Radiation	T		T	4.5.2.6.7

Specification		Test Level and Method			Verification
Paragraph Number	Parameter Name	DQT	PAT	TT	Paragraph
3.2.6.7.1	Voltage Standing Wave Ratio (VSWR) Protection	D		D	4.5.2.6.7.1
3.2.6.8	Inter-Pulse Output Level	T		T	4.5.2.6.8
3.2.6.9	Retriggering of Transponder	T		T	4.5.2.6.9
3.2.6.10	E.I.R.P	A			4.5.2.6.10
3.2.7	Stabilization of Performance Characteristics	D	D	D	4.5.2.7
3.2.8	Duty Cycle Overload Protection	D		D	4.5.2.8
3.2.9	Thermal Overload Protection	D		D	4.5.2.9
3.3	**Antenna Requirements**				
3.3.1	Antenna Type	I	I	I	4.5.3
3.3.2	Frequency Range	T		T	4.5.3
3.3.3	Polarization	T			4.5.3
3.3.4	Characteristic Impedance and VSWR	T	T	T	4.5.3
3.3.5	Antenna Gain	T		T	4.5.3
3.3.5 a.	Omni	T		T	4.5.3
3.3.5 b.	Directional	T		T	4.5.3
3.3.6	Vertical Pattern				4.5.3
3.3.6-1	Vertical Pattern	T		T	4.5.3
3.3.6-2	Vertical Pattern	T		T	4.5.3
3.3.6-3	Vertical Pattern	T		T	4.5.3
3.3.6-4	Vertical Pattern	T		T	4.5.3
3.3.6-5	Vertical Pattern	T		T	4.5.3
3.3.6-6	Vertical Pattern	T		T	4.5.3
3.3.6-7	Vertical Pattern	T		T	4.5.3
3.3.7	Horizontal Pattern	T		T	4.5.3
3.3.8	Radome and Weatherproofing	I	I	I	4.5.3
3.3.9	Antenna Mount	I	I	I	4.5.3
3.3.10	Vibration, Wind, and Ice Loading	T			4.5.3
3.3.11	Monitor Probes	T	T	T	4.5.3
3.3.12	Antenna Cables	I	I	I	4.5.3
3.3.13	Obstruction Lights	I	I	I	4.5.3
3.3.14	Power Handling	D			4.5.3
3.4	**Monitor**				**4.5.4**
3.4.1	Operating Channels	T		T	4.5.4.1
3.4.1.1	Frequency and Accuracy Stability	T		T	4.5.4.1.1
3.4.2	Monitor RF Input/Output Signal Coupling	T		T	4.5.4.2
3.4.3	Interrogation Signal Generator	D		D	4.5.4.3
3.4.3.1	Operational Modes	D	D	D	4.5.4.3.1
3.4.3.2	Pulse Synchronization Output	D	D	D	4.5.4.3.2
3.4.3.3	RF Output Pulse Signal	T	T	T	4.5.4.3.3
3.4.3.3.1	Rise Time	T		T	4.5.4.3.3.1
3.4.3.3.2	Pulse Top	T		T	4.5.4.3.3.2
3.4.3.3.3	Pulse Duration	T	T	T	4.5.4.3.3.3
3.4.3.3.4	Decay Time	T		T	4.5.4.3.3.4
3.4.3.4	Pulse Coding	T	T	T	4.5.4.3.4

Specification		Test Level and Method			Verification
Paragraph Number	Parameter Name	DQT	PAT	TT	Paragraph
3.4.3.5	Pulse Power Variation	T		T	4.5.4.3.5
3.4.3.6	Detected RF Output Signal	T		T	4.5.4.3.6
3.4.3.7	RF Pulse Spectrum	T		T	4.5.4.3.7
3.4.3.8	Spurious Output	T		T	4.5.4.3.8
3.4.3.9	Test RF Output Freq.	T		T	4.5.4.3.9
3.4.3.10	RF Output Level Calibration	T		T	4.5.4.3.10
3.4.3.11	RF Output Level and Accuracy	T	T	T	4.5.4.3.11
3.4.4	Transponder Monitor				4.5.4.4
3.4.4.1	Monitor Alarm Action	D	D	D	4.5.4.4.1
3.4.4.1 PA a.	Monitor Alarm Action	D	D	D	4.5.4.4.1
3.4.4.1 PA b.	Monitor Alarm Action	D	D	D	4.5.4.4.1
3.4.4.1 PA c.	Monitor Alarm Action	D	D	D	4.5.4.4.1
3.4.4.1 PA d.	Monitor Alarm Action	D	D	D	4.5.4.4.1
3.4.4.1 PA e.	Monitor Alarm Action	D	D	D	4.5.4.4.1
3.4.4.1 SA a.	Monitor Alarm Action	D	D	D	4.5.4.4.1
3.4.4.1 SA b.	Monitor Alarm Action	D	D	D	4.5.4.4.1
3.4.4.1 SA c.	Monitor Alarm Action	D	D	D	4.5.4.4.1
3.4.4.1.1	Alarm Delay Time	T	T	T	4.5.4.4.1.1
3.4.4.1.2	Monitor Response Time	T	T	T	4.5.4.4.1.2
3.4.4.2	Monitored Parameter Fault Thresholds				
3.4.4.2.1	Required Parameters	T		T	4.5.4.4.2.1
3.4.4.2.1 a.	Reply Efficiency Monitor	T		T	4.5.4.4.2.1
3.4.4.2.1 b.	Reply Delay Monitor	T	T	T	4.5.4.4.2.1
3.4.4.2.1 c.	Output Pulse Spacing Monitor	T		T	4.5.4.4.2.1
3.4.4.2.1 d.	Transponder Pulse Rate Monitor	T		T	4.5.4.4.2.1
3.4.4.2.1 e.	Transponder Radiated Power Monitoring	T		T	4.5.4.4.2.1
3.4.4.2.1 f.	Output Power	T		T	
3.4.4.2.1 g.	Ident Signal Monitoring	T		T	4.5.4.4.2.1
3.4.4.2.1 h.	Transponder Receiver and Transmitter Frequencies	T		T	4.5.4.4.2.1
3.4.4.3	Test Signals and Monitoring Activities	T		T	4.5.4.4.3
3.5	**Control / Status / Indicator Functions**	D			4.5.5
3.5.1	Control Functions				4.5.5
3.5.1 a.	Control Functions	D			4.5.5
3.5.1 b.	Control Functions	D			4.5.5
3.5.1 c.	Control Functions	D			4.5.5
3.5.1 d.	Control Functions	D			4.5.5
3.5.1.1	Local / Remote Control Functions	D			4.5.5
3.5.1.2	Local Control Functions	D			4.5.5
3.5.1.3	Remote Control Functions				4.5.5
3.5.1.3 a.	Remote Control Functions	D			4.5.5
3.5.1.3 b.	Remote Control Functions	D			4.5.5
3.5.1.3 c.	Remote Control Functions	D			4.5.5
3.5.1.3 d.	Remote Control Functions	D			4.5.5
3.5.1.3 e.	Remote Control Functions	D			4.5.5
3.5.1.3 f.	Remote Control Functions	D			4.5.5
3.5.1.3 g.	Remote Control Functions	D			4.5.5

Specification		Test Level and Method			Verification
Paragraph Number	Parameter Name	DQT	PAT	TT	Paragraph
3.5.1.4	Automatic Reset Function	D			4.5.5
3.5.1.4 a.	Automatic Reset Function	D			4.5.5
3.5.1.4 b.	Automatic Reset Function	D			4.5.5
3.5.1.4 c.	Automatic Reset Function	D			4.5.5
3.5.2	Status Functions	D			4.5.5
3.5.2.1	Local / Remote Status Functions				4.5.5
3.5.2.1 a.	Local / Remote Status Functions	D			4.5.5
3.5.2.1 b.	Local / Remote Status Functions	D			4.5.5
3.5.2.1 c.	Local / Remote Status Functions	D			4.5.5
3.5.2.1 d.	Local / Remote Status Functions	D			4.5.5
3.5.2.1 e.	Local / Remote Status Functions	D			4.5.5
3.5.2.1 f.	Local / Remote Status Functions	D			4.5.5
3.5.2.1 g.	Local / Remote Status Functions	D			4.5.5
3.5.2.2	Local Status Functions	D			4.5.5
3.5.2.3	Remote Status Functions				4.5.5
3.5.2.3 a.	Remote Status Functions	D			4.5.5
3.5.2.3 b.	Remote Status Functions	D			4.5.5
3.5.2.3 c.	Remote Status Functions	D			4.5.5
3.5.2.3 d.	Remote Status Functions	D			4.5.5
3.5.2.3 e.	Remote Status Functions	D			4.5.5
3.5.3	Indicator Functions	D			4.5.5
3.5.3.1	Local / Remote Indicator Functions				4.5.5
3.5.3.1 a.	Local / Remote Indicator Functions	D			4.5.5
3.5.3.1 b.	Local / Remote Indicator Functions	D			4.5.5
3.5.3.1 c.	Local / Remote Indicator Functions	D			4.5.5
3.5.3.1 d.	Local / Remote Indicator Functions	D			4.5.5
3.5.3.2	Local Indicator Functions				4.5.5
3.5.3.2 a.	Local Indicator Functions	D			4.5.5
3.5.3.2 b.	Local Indicator Functions	D			4.5.5
3.5.3.3	Remote Indicator Functions	D			4.5.5
3.6	**Remote Monitoring System**	D			4.5.6
3.6.1	Additional Requirements				4.5.6
3.6.1 a.	Additional Requirements	D			4.5.6
3.6.1 b.	Additional Requirements	D			4.5.6
3.6.1 c.	Additional Requirements	D			4.5.6
3.6.1 d.	Additional Requirements	D			4.5.6
3.6.1 e.	Additional Requirements	D			4.5.6
3.6.1 f.	Additional Requirements	D			4.5.6

4.4 Test Set Descriptions.

4.4.1 Test Set A. Must be able to generate a single RF signal that can replicate a DME channel interrogation pulse pair with correct interrogation pulse characteristics. Must be able to adjust parameters of RF signal. These parameters include frequency and all pulse characteristics.

4.4.2 Test Set B. Must be able to generate multiple RF signals that can replicate a DME channel interrogation pulse pair with correct interrogation pulse characteristics. Must be able to adjust parameters of RF signal. These parameters include frequency and all pulse characteristics.

4.4.3 Test Set C. - Must be able to generate all monitored DME transponder signals with appropriate parameters as specified by section 6.1, definitions, of this document. The test set must also be able to vary the parameters of these signals so that an out-of-tolerance signal can be emulated.

4.5 Generalized Procedures.

4.5.1 General Requirements.

4.5.1.1 Modular Construction.
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.1 by inspecting the equipment and reviewing the instruction book.

4.5.1.2 Primary Power Source.
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.2 by inspecting the equipment and reviewing the instruction book.

4.5.1.3 Solid State Design.
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.3 by inspecting the equipment and reviewing the instruction book.

4.5.1.4 Test Points and Connectors.
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.4 by inspecting the equipment and reviewing the instruction book.

4.5.1.5 Interlock Signal from ILS.
Test equipment needed:
Interlock signal (simulated or real).

Verification procedure: Interlock can be verified using an ILS interlock signal or by using a power supply to serve as an ILS interlock signal.

1. Verify the DME system has interlock enabled as directed by the instruction manual.
2. Connect the interlock signal to the DME transponder as instructed by the instruction manual.
3. Turn off the interlock signal (ILS or power supply). The DME should be off.
4. Turn the Interlock signal (ILS or power supply) back on and the DME should resume operation after the power-on sequence is successfully completed.
5. Verify the system meets requirements in paragraph 3.1.5.

4.5.1.6 Battery Backup.

Test equipment needed: None.

Verification procedure:

1. Ensure the transponder equipment is operating on AC power with fully charged batteries.
2. Remove AC power.
3. The transponder equipment shall run on backup power to verify the system meets requirements in paragraph 3.1.6.

4.5.1.7 Equipment Cabinet.

Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.7 by inspecting the equipment and reviewing the instruction book.

4.5.1.8 DME Purpose.

Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.8 by demonstrating the functionality of the equipment and reviewing the instruction book.

4.5.1.9 Range.

Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.9 by analyzing data provided by the equipment manufacturer and reviewing the instruction book.

4.5.1.10 Coverage.

Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.10 by analyzing data provided by the equipment manufacturer and reviewing the instruction book.

4.5.1.11 Accuracy.

4.5.1.11.1 System Accuracy.
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.11.1 by testing the equipment and reviewing the instruction book.

4.5.1.11.2 DME Accuracy.
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.11.2 by testing the equipment and reviewing the instruction book.

4.5.1.11.3 Transponder Capacity.
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.11.3 by analyzing data provided by the equipment manufacturer and reviewing the instruction book.

4.5.1.12 Maintainability.
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.12 by demonstrating the functionality of the equipment and reviewing the instruction book.

4.5.1.13 Reliability.
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.13 by analyzing data provided by the equipment manufacturer, reviewing the instruction book, and demonstration of the functionality.

4.5.1.14 Continuity of Service.
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.14 by analyzing data provided by the equipment manufacturer and reviewing the instruction book.

4.5.1.15 Integrity of Signal.

Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.15 by analyzing data provided by the equipment manufacturer and reviewing the instruction book.

4.5.1.16 Security.
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.16 by demonstrating the equipment functionality and reviewing the instruction book.

4.5.1.17 Operational Environmental Conditions.
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.17 by testing the equipment to the best extent possible and reviewing the instruction book.

4.5.1.18 Electromagnetic Interference (EMI).
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.18 by analyzing data provided by the equipment manufacturer and reviewing the instruction book.

4.5.1.18.1 Electromagnetic Compatibility (EMC).
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.1.18.1 by analyzing data provided by the equipment manufacturer and reviewing the instruction book.

4.5.1.19 Operation of Overload Protective Devices.
Test equipment needed: None

Verification procedure: Demonstration of the ability of the system to meet requirements in paragraph 3.1.19.

4.5.1.20 Static Discharge.
Test equipment needed: None

Verification procedure: Demonstration of the ability of the system to meet requirements in paragraph 3.1.20.

4.5.1.21 Grounding and Bonding.
Test equipment needed: None

Verification procedure: Demonstration of the ability of the system to meet requirements in paragraph 3.1.21.

4.5.2 Transponder Requirements.

4.5.2.1 Operating Channels.

Test equipment needed:
Frequency counter or equivalent.

Verification procedure:

1. The DME system shall be in normal operational mode;
2. A frequency counter shall be connected to the appropriate test points of the system to measure frequency;
3. The system will then be set to the following frequencies and verified to be in normal operational mode. A reading from the frequency counter shall be taken at each frequency:
   Low band – 962 MHz (channel 1X)
   Mid-low band – 1025 MHz (channel 63X)
   Mid band – 1088 MHz (channel 1Y)
   Mid-high band – 1150 MHz (channel 63Y)
   High band – 1213 MHz (channel 126X).

Testing additional frequencies to confirm dynamic frequency range is recommended. From the frequency counter reading the transponder output shall meet requirements in paragraph 3.2.1.

4.5.2.1.1 Channel Frequency and Stability.

Test equipment needed: See paragraph 4.5.2.1.

Verification procedure: Verify the readings from paragraph 4.5.2.1 meet the requirements in paragraph 3.2.1.1.

4.5.2.2 Receiver and Video Circuitry.

4.5.2.2.1 Receiver Bandwidth and Stability.

Test equipment needed:
Test set A to input a DME signal to the system with a +/-100kHz offset (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure:
This can be measured by collecting reply efficiency data from the system utilizing an interrogation signal sent to the system with an offset of at least +/- 100 kHz of the current interrogation frequency.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode. The frequency counter reading at the interrogation frequency shall be recorded.
3. Inject the +100 kHz offset signal using the test set. The frequency counter reading at the offset frequency shall be recorded.
4. Inject the -100 kHz offset signal using the test set. The frequency counter reading at the offset frequency shall be recorded.
5. Using the readings verify that the system meets requirements in paragraph 3.2.2.1.

4.5.2.2.1.1 Receiver Bandwidth.

Test equipment needed: See paragraph 4.5.2.2.1.

Verification procedure: Using the measurements obtained from the verification procedure stated in paragraph 4.5.2.2.1 verify that the system meets the requirements in paragraph 3.2.2.1.1.

4.5.2.2.2 Receiver Decoder.

Test equipment needed:
Test Set A to input a DME signal to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure:
The test set and the system instruction book shall be used to inject an interrogation signal with pulse spacing and duration appropriate to interrogator signals as described by ICAO Annex 10, Volume 1, paragraphs 3.5.5.1.3 and 3.5.5.1.4.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. The number of valid interrogations is measured.
4. Using the measurements verify that the system meets requirements in paragraph 3.2.2.2.

4.5.2.2.2.1 Decoding Circuit Performance.

Test equipment needed:
Test Set A to input a DME signal to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject signals that will appear before, after and in between valid interrogation signal pulse pairs.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. Reply efficiency and reply delay shall be checked and recorded to confirm no performance degradation during the injected signal duration.

4. Using the measurements verify the system meets requirements in paragraph 3.2.2.2.1.

4.5.2.2.2.2 Decoder Rejection Pulse Spacing.

Test equipment needed:
Test Set A to input a DME signal to the system (i.e. arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject interrogation pulse pairs with pulse spacing out of tolerance.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. The number of valid interrogations shall be measured to verify that injected interrogations were rejected.
4. Use the measurements to verify the system meets requirements in paragraph 3.2.2.2.2.

4.5.2.2.2.3 Decoder Rejection Pulse Width.

Test equipment needed:
Test Set A to input a DME signal to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject interrogation pulse pairs with pulse spacing out of tolerance.

5. Connect the test set to the appropriate test points.
6. Confirm the DME is in operational mode.
7. The number of valid interrogations shall be measured to verify that injected interrogations were rejected.
8. Use the measurements to verify the system meets requirements in paragraph 3.2.2.2.3.

4.5.2.2.3 Receiver Dead Time.

Test equipment needed:
Test Set B to input two DME signals to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject a valid interrogation signal. An additional interrogation shall be injected inside the dead time gate and a measurement of valid interrogations shall be taken to confirm the interrogation received inside the dead time gate was not replied to. To confirm measurement the additional interrogation shall then be injected outside the dead time gate and a measurement of valid interrogations shall be taken to confirm the additional interrogation was replied to.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. Inject the second signal inside the dead time gate. A frequency counter reading of valid interrogations shall be recorded.
4. Inject the second signal outside the dead time gate. A frequency counter reading of valid interrogations shall be recorded.
5. Use the measurements to verify the system meets requirements in paragraph 3.2.2.3.

4.5.2.2.4 Receiver Recovery Time.

Test equipment needed:
Test Set B to input two DME signals to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject a valid interrogation signal and also an interrogation signal with pulse spacing out of tolerance 8 μs before the valid interrogation.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. Inject the out of tolerance signal 8 μs before the valid interrogation signal. Reply efficiency shall be measured to confirm no degradation of system performance.
4. Use the measurements to verify the system meets requirements in paragraph 3.2.2.4.

4.5.2.2.5 Echo Suppression.

4.5.2.2.5.1 Short Distance Echoes.

Test equipment needed:
Test Set B to input two DME signals to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject signals that will appear on the leading edge and falling edge of the second pulse of the valid interrogation.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. A measurement shall be taken of reply efficiency and reply delay for a valid interrogation signal without echoes.
4. Confirm the DME is in operational mode and short-distance echo suppression is enabled.
5. The echo signal then will be injected and a reply efficiency and reply delay reading will be taken.
6. Reply efficiency and reply delay results shall be compared and checked to confirm no performance degradation during the injected echo signal duration.

7. Use the measurements to verify the system meets requirements in paragraph 3.2.2.5.1.

4.5.2.2.5.2 Long Distance Echoes.

Test equipment needed:
Test Set B to input two DME signals to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject interrogation signals that will appear inside the long distance echo suppression window required by paragraph 3.2.2.5.2.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. A frequency counter measurement shall be taken of the number of valid interrogations without echoes.
4. Confirm the DME is in operational mode and long-distance echo suppression is enabled.
5. The test set shall be used to inject a second interrogation inside the echo threshold. A measurement shall be made to confirm the number of valid interrogations is the same showing the long distance echo suppression is valid.
6. The test set shall then be used to inject an interrogation signal outside the echo threshold. A new measurement will then be made to confirm the number of interrogations has increased showing valid interrogations outside of the long distance echo suppression window will trigger reply pulses.
7. Use the measurements to verify the system meets requirements in paragraph 3.2.2.5.2 a-f.

4.5.2.2.5.3 Echo Suppression Disable.

Test equipment needed: None.

Verification procedure: Confirm that the echo suppression can be disabled for normal operation as per paragraph 3.2.2.5.3. Repeat procedures 1-4 from paragraphs 4.5.2.2.5.1 and 4.5.2.2.5.2 to confirm the echo suppression is disabled.

4.5.2.2.5.4 DME Traffic Load Monitoring.

Test equipment needed: None.

Verification procedure: Confirmed in procedures 4.5.2.2.5.1 and 4.5.2.2.5.2.

4.5.2.2.6 Receiver Sensitivity.

Test equipment needed:
Test Set A to input a DME signal to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject a valid interrogation with a signal level above the sensitivity threshold.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. The test set shall be used to inject an interrogation signal with a signal level above threshold. A frequency counter reading shall be taken to confirm that 70 percent or more of the interrogations injected by the test set are replied to by the DME.
4. Use the frequency counter reading to verify the system meets requirements in paragraph 3.2.2.6.

4.5.2.2.6.1 On Channel Sensitivity.

Test equipment needed:
Test Set A to input a DME signal to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject a valid interrogation with a signal level at the sensitivity threshold and below.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. The test set shall be used to inject an interrogation signal with a signal level at threshold. A frequency counter reading shall be taken to confirm that 70 % or more of the interrogations injected by the test set are replied to by the DME.
4. Use the frequency counter reading to verify the system meets requirements in paragraph 3.2.2.6.1.

4.5.2.2.6.1.1 Sensitivity Variation with Interrogation Loading.

Test equipment needed:
Test Set A to input a DME signal to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: Repeat 4.5.2.2.6.1 with varying levels of interrogation loading ranging from zero (0) % to 90 % and take measurements of valid replies to verify the system meets requirements in paragraph 3.2.2.6.1.1.

4.5.2.2.6.1.2 Sensitivity at Other Pulse Spacing.

Test equipment needed:
Test Set A to input a DME signal to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Procedure: Repeat 4.5.2.2.6.1 with injected interrogation signal pulse spacing of nominal spacing +/- 1 μs. Take measurements of reply efficiency to verify the system meets requirements in paragraph 3.2.2.6.1.2.

4.5.2.2.6.1.3 Desensitization by Adjacent Channel Interrogation.
Test equipment needed:
Test Set B to input two DME signals to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject a valid interrogation with a signal level at the sensitivity threshold. A second interrogation signal identical to the valid signal shall be injected into the system with an interrogation frequency offset of +/- 900 kHz and signal level up to –10 dBm.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. The test set shall be used to inject a valid interrogation with a signal level at threshold. A frequency counter reading shall be taken and used to calculate how many of the interrogations injected by the test set are replied to by the DME.
4. A second signal shall be injected with the same pulse characteristics and a frequency offset of +900 kHz at a signal level beginning at –40 dBm and increased to –10 dBm. Frequency counter readings shall be taken and compared to the initial reading to confirm no degradation has occurred.
5. A second signal shall be injected with the same pulse characteristics and a frequency offset of -900 kHz at a signal level beginning at –40 dBm and increased to –10 dBm. Frequency counter readings shall be taken and compared to the initial reading to confirm no degradation has occurred.
6. Using the measurements, verify the system meets the requirements in paragraph 3.2.2.6.1.3.

4.5.2.2.6.1.4 Desensitization by Continuous Wave (CW).
Test equipment needed:
Test Set B to input two DME signals to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification Procedure: The test set and the system instruction book shall be used to inject a valid interrogation with a signal level at the sensitivity threshold. A CW signal shall be injected into the system with a signal level 10 dB or more below the threshold triggering level.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. The test set shall be used to inject a valid interrogation signal. An initial frequency counter reading shall be taken.
4. The test set shall then be used to inject the CW signal at 10 dB below the threshold. A frequency counter reading shall be taken.
5. The frequency counter readings will be compared to the initial reading to verify any degradation that might have occurred is within tolerances given by paragraph 3.2.2.6.1.4.

6. The interrogation signal shall then have its signal level changed to 6 dB below the level of the valid signal and a measurement of reply efficiency shall be made to verify the requirements of paragraph 3.2.2.6.1.4.

4.5.2.2.6.1.5 Desensitization by High Repetition Rate/High Duty Cycle Pulse Signals.

Test equipment needed:
Test Set B to input two DME signals to the system (i.e. arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject a valid interrogation with a signal level at the sensitivity threshold. A second interrogation signal identical to the valid signal shall be injected into the system with an interrogation signal level 10 dB below the on channel sensitivity threshold level and a repetition rate of 37,000 pulses per second.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. The test set shall be used to inject a valid interrogation with a signal level at threshold. A frequency counter reading shall be taken and used to calculate how many of the interrogations injected by the test set are replied to by the DME.
4. A second signal shall be injected with the same pulse characteristics with a signal level at 10 dB below the signal level threshold and a repetition rate of 37000 pulses per second. Frequency counter readings shall be taken and compared to the initial reading to confirm no degradation has occurred.
5. Using the measurements verify the system meets the requirements in paragraph 3.2.2.6.1.5.

4.5.2.2.6.2 Sensitivity to Adjacent Channel Interrogations.

Test equipment needed:
Test Set A to input a DME signal to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject a valid interrogation with a signal level at the sensitivity threshold with an interrogation frequency offset of +/- 900 kHz.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. The test set shall be used to inject an interrogation signal with offset of +900 kHz. A measurement of reply efficiency shall be taken.
4. The test set shall be used to inject an interrogation signal with offset of -900 kHz. A measurement of reply efficiency shall be taken.
5. Use the measurements to verify the system meets requirements in paragraph 3.2.2.6.2.

4.5.2.2.6.3 Dynamic Range.

Test equipment needed:
Test Set A to input a DME signal to the system (i.e. arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject a valid interrogation with a signal level at the sensitivity threshold.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. The test set shall be used to inject an interrogation signal with a signal level at the sensitivity threshold. A reply efficiency measurement will be made using the frequency counter.
4. The signal level shall then be changed to –10 dBm and a measurement of reply efficiency shall be taken.
5. The signal level shall be changed to at least two other levels within the range of the max (-10 dB) and min (sensitivity threshold).
6. Use the measurements to verify the system meets requirements of paragraph 3.2.2.6.3.

4.5.2.2.6.4 Noise Generated Pulse Pairs.

Test equipment needed:
Test Set A to input a DME signal to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject a valid interrogation with a signal level at the sensitivity threshold and transmission rate of 90 % of maximum.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. The test set shall be used to inject a valid interrogation at the sensitivity threshold and 90% of max transmission rate.
4. A measurement of the number of replies shall be made using the frequency counter and the appropriate test points.
5. Use the measurement to verify the system meets requirements of paragraph 3.2.2.6.4.

4.5.2.2.7 Reply Efficiency.

Test equipment needed:
Test Set A to input a DME signal to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure: The test set and the system instruction book shall be used to inject a valid interrogation with a signal level at the sensitivity threshold.

1. Connect the test set to the appropriate test points.
2. Confirm the DME is in operational mode.
3. A measurement of the number of replies shall be made using the frequency counter and the appropriate test points.
4. Reply efficiency will then be checked to verify the system meets requirements of paragraph 3.2.2.7.

4.5.2.2.8 Interference Suppression.

Test equipment needed:
Spectrum analyzer

Verification procedure: The following procedures will be conducted for the preset DME power levels of 100 watts and 1000 watts.

1. Set up a spectrum analyzer connected to the output of the transponder with 40 dBm attenuation and then set trigger to FREE RUN. Watch for spurs caused by the spectrum analyzer.
2. Set the spectrum analyzer resolution and video bandwidths at 10 kHz each, set the span to 10MHz (settings may vary with model of analyzer).
3. Examine the intermediate frequency to check for any spurious output.
4. Record the level of the highest spur at the intermediate frequency.
5. Examine and (if possible) plot the spectrum of the output signal over the range of 10 MHz to 1800 MHz.
6. Record the level of the highest spur.
7. Use the measurements to verify the system meets requirements in paragraph 3.2.2.8.

4.5.2.2.9 Random Squitter Pulses.

Test equipment needed:
Frequency counter.

Verification procedure:

1. Connect the frequency counter to the appropriate test points to measure the number of replies.
2. Confirm the DME is in operational mode and no interrogation is being injected to the system.
3. Measure the number of replies during normal operation of the system with zero (0) % loading.
4. Use the measurement to verify the system meets requirements in paragraph 3.2.2.9.

4.5.2.2.9.1 Effect of Traffic Loading.

Test equipment needed:
Frequency counter.

Verification procedure:

1. Connect the frequency counter to the appropriate test points to measure the number of replies.
2. Confirm the DME is in operational mode and no interrogation is being injected to the system.
3. Measure the number of replies during normal operation of the system with zero (0) % loading.
4. Use the measurement to verify the system meets requirements in paragraph 3.2.2.9.1.

4.5.2.2.10 Automatic Gain Reduction (AGR).

Test equipment needed:
Test Set B to input two DME signals to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter

Verification Procedure: Test Set B will be used to input two interrogation signals to the transponder.

1. Connect test set b to the appropriate test points of the transponder.
2. Connect the frequency counter to the appropriate test points to measure the number of transponder replies.
3. Confirm the DME is in operational mode and no interrogation is being injected to the system.
4. Use test set B to inject two interrogation signals.
5. The first signal will be at -40 dB signal level and have a repetition rate of 80 % of the maximum transmission rate.
6. The second signal will have a signal level at the sensitivity threshold and a repetition rate of five (5) % of the maximum transmission rate.
7. Take a reading form the frequency counter to confirm that all interrogations are being replied to by the transponder.
8. Increase the second signal repetition rate to above 10 % of the maximum transmission rate.
9. Take a reading form the frequency counter.
10. Use the Measurement to verify the system meets the requirements in paragraph 3.2.2.10.

4.5.2.2.11 Priority of Transmission.

Test equipment needed:
Test Set A to input a DME signal to the system (i.e., arbitrary waveform generator, signal generator). Test equipment internal to the DME system can also be used.
Frequency counter.

Verification procedure:

1. Connect the test set to the appropriate test points.
2. Confirm DME is in operational mode.

3. The test set shall be used to inject a valid interrogation and transmission rate of 90 % max. Measure the number of replies during normal operation of the system with 90 % loading during an identity transmission.
4. Measure the number of replies during normal operation of the system with 90 % loading not during an identity transmission.
5. Measure the number of replies during normal operation of the system with zero (0) % loading during an identity transmission.
6. Measure the number of replies during normal operation of the system with zero (0) % loading not during an identity transmission.
7. Use the measurements to verify the system meets requirements in paragraph 3.2.2.11.

4.5.2.3 Identification Signals and Keying.

Test equipment needed:
Frequency Counter.

Verification procedure:
1. Connect the frequency counter to the appropriate test points.
2. Set the frequency counter to measure frequency rate.
3. Confirm DME is in operational mode and that identification is set to constant.
4. Take a measurement from the frequency counter.
5. Use the measurement to verify the system meets requirements in paragraph 3.2.3.

4.5.2.3.1 Identification Keying Control.

Test equipment needed:
ILS identification signal (real or simulated)

Verification procedure: Test the system to show identification can be controlled from an external source such as an ILS (real or simulated).
1. Connect the ILS identification signal to the appropriate test points.
2. Confirm DME is set to trigger off of an external source for identification.
3. Verify the DME is in operational mode.
4. This shall verify the requirements in paragraph 3.2.3.1.

4.5.2.3.2 Identity Keying Control.

Test equipment needed: None.

Verification procedure: Verify manual control is provided on each transponder to enable (1) normal identification keying, (2) removal of identification keying, and (3) continuous transmission of identification signal pulse groups. The manual control shall be used to select each mode (1, 2, and 3) and appropriate operation of identification keying control verified against each selected mode. Use the actions to verify the system meets requirements in paragraph 3.2.3.2.

4.5.2.3.3 Independent Identification Signal Characteristics.

Test equipment needed:

Oscilloscope

Verification procedure:

1. Connect the oscilloscope to the appropriate test points.
2. Set the oscilloscope so that a whole identification can be seen on screen.
3. Confirm DME is in operational mode and that identification is set to constant.
4. Take a measurement from the oscilloscope so the identification can be seen.

Use the measurement to verify the system meets requirements in paragraph 3.2.3.3.

4.5.2.3.4 Associated Identification Signal Characteristics.

Test equipment needed: None.

Verification procedures: Using the procedure and information from verification procedure 4.5.2.3.1 confirm that the system meets the requirements in paragraph 3.2.3.4.

4.5.2.4 Transmitter and Associated Circuitry.

4.5.2.4.1 Tuning and Spurious Output.

Test equipment needed:
Spectrum analyzer; 30 dB attenuator; 20 dB attenuator.

Verification procedure:

1. Setup a spectrum analyzer connected to the transponder using 30 db of attenuation on the output of the transponder.
2. Set the center frequency of the spectrum analyzer to the output frequency of the transponder. Set the frequency span to 0 Hz, the Resolution bandwidth to 3 MHz, the Video bandwidth to 3 MHz, and the Sweep time to 10 or 20 usec. Push the video trigger button.
3. Add 20 dB of attenuation to the input of the spectrum analyzer.
4. Verify the transponder is enabled.
5. Use the Reference level control to set the pulse peaks at the top line of the display graticule.
6. Move the display line to –60 db with respect to the top line (this will be –80 db when the 20 db attenuator is removed).
7. Remove the 20 db attenuator and reconnect the cable.
8. Verify there is a 1 microsecond period between the pulses where the level is below 60 db (80 db) on the analyzer.
9. Use the measurements to verify the system meets requirements in paragraph 3.2.4.1.

4.5.2.4.2 RF Output Power Control.

Test equipment needed:
Peak power meter; variable attenuator

Verification procedure:

1. The power meter shall be directly attached to the output of the transponder and an initial power reading will be made.
2. The output power of the transponder will then be adjusted by 1 dB below maximum. A power reading will be made and compared to the initial reading to confirm a 1 dB drop in power.
3. The output power of the transponder will then be adjusted by 2 dB below maximum. A power reading will be made and compared to the initial reading to confirm a 2 dB drop in power.
4. The output power of the transponder will then be adjusted by 3 dB below maximum. A power reading will be made and compared to the initial reading to confirm a 3 dB drop in power.
5. The output power of the transponder will then be adjusted by 4 dB below maximum. A power reading will be made and compared to the initial reading to confirm a 4 dB drop in power.
6. Use the readings to verify the system meets requirements in paragraph 3.2.4.2.

4.5.2.4.3 Reply Delay Values and Adjustments.

Test equipment needed:
Oscilloscope

Verification procedure: Verify the transponder reply delay can be adjusted. This can be validated using an oscilloscope and the system instruction manual to determine the correct test point to monitor.

1. Connect the oscilloscope to the appropriate test points.
2. Set and confirm that the DME is in operational mode on an X channel.
3. Take an initial measurement for reply delay from the oscilloscope.
4. Adjust the reply delay of the DME to 35 μs.
5. Use the oscilloscope to verify the reply delay has changed to 35 μs.
6. Adjust the reply delay of the DME to 51 μs.
7. Use the oscilloscope to verify the reply delay has changed to 51 μs.
8. Set and confirm that the DME is in operational mode on a Y channel.
9. Take an initial measurement for reply delay from the oscilloscope.
10. Adjust the reply delay of the DME to 46 μs.
11. Use the oscilloscope to verify the reply delay has changed to 46 μs.
12. Adjust the reply delay of the DME to 50 μs.
13. Use the oscilloscope to verify the reply delay has changed to 50 μs.
14. Use the measurements to verify the system meets the requirements in paragraph 3.2.4.3.

4.5.2.4.4 Accuracy.

Test equipment needed: None.

Verification procedures: Data shall be obtained and analyzed that can effectively indicate the system shall meet the requirements in paragraph 3.2.4.4.

4.5.2.5 Power Delay Control and Adjustment.

4.5.2.5.1 Local High Voltage Control.

Test equipment needed: None.

Verification procedure: Verify a means by which the high voltage power can be turned off. This can be a manual switch or located in the system interface. The demonstration shall verify requirements in paragraph 3.2.5.1.

4.5.2.6 Transponder Output Signals.

4.5.2.6.1 Pulse Shape.

Test equipment needed:
Oscilloscope

Verification procedure: Using an oscilloscope and the system instruction book, the pulse shape characteristics can be measured and recorded.

1. Connect the oscilloscope to the appropriate test points.
2. Confirm the DME is in operational mode.
3. Use the oscilloscope to manually or automatically (depending on oscilloscope) measure the pulse shape characteristics in the following paragraphs 4.5.2.6.1.1 through 4.5.2.6.1.4.
4. Use the measurements to verify the pulse shape meets requirements in paragraph 3.2.6.1, and 3.2.6.1.1 through 3.2.6.1.4.

4.5.2.6.1.1 Rise Time.

Verification procedure: Use the procedures given in 4.5.2.6.1 to measure the rise time from the 10 % point to 90 % point of the rising edge. Pulse rise time shall not be more than 3 μs nor be less than 1.5 μs in accordance with paragraph 3.2.6.1.1.

4.5.2.6.1.2 Pulse Top.

Verification procedure: Use the procedures given in 4.5.2.6.1 to measure the instantaneous amplitude of the pulse which shall not, at any instant between the point of the leading edge which is 95 % of maximum amplitude and the point of the trailing edge which is 95 % of the maximum amplitude, fall below a value which is 95 % of the maximum voltage amplitude of the pulse. Use the measurements to verify the pulse top meets requirements in paragraph 3.2.6.1.2.

4.5.2.6.1.3 Pulse Duration.

Verification procedure: Use the procedures given in 4.5.2.6.1 to measure the pulse duration from the 50 % point of the rising edge to the 50 % point of the falling edge. Tolerance shall be 3.5 μs plus or minus 0.5 μs in accordance with paragraph 3.2.6.1.3.

4.5.2.6.1.4 Decay Time.

Verification procedure: Use the procedures given in 4.5.2.6.1 to measure the decay time from the 90 % point to 10 % point of the falling edge. Pulse decay time shall nominally be 2.5 μs but shall not be more than 3.5 μs nor be less than 1.5 μs in accordance with paragraph 3.2.6.1.4.

4.5.2.6.1.5 Instantaneous Magnitude.

Verification procedure: Use the procedures given in 4.5.2.6.1 to measure the pulse shape and using Figure 7 measure the instantaneous magnitude to confirm the system meets the requirements in paragraph 3.2.6.1.5.

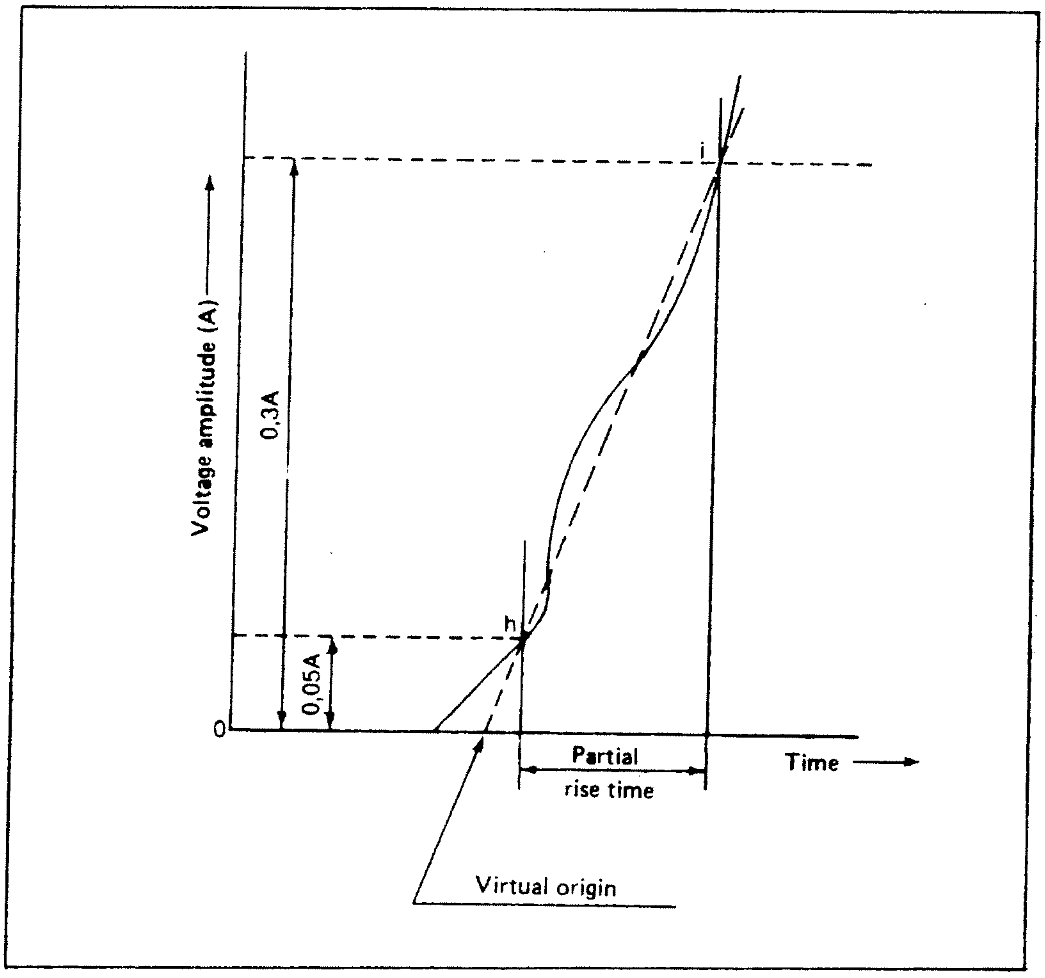

Figure 7. Virtual Origin

4.5.2.6.2 Pulse Coding.

Test equipment needed:
Oscilloscope

Verification procedure: Using an oscilloscope and the system instruction manual the pulse spacing can be measured and recorded. Pulses shall be coded in pairs with a spacing, as measured between the 50 percent maximum voltage amplitude point on the leading edge of the first RF pulse to the corresponding point on the leading edge of the second RF pulse, of (a) 12 (±0.25) μs for "X" channels or, (b) 30 (±0.25) μs for "Y" channels.

1. Connect the oscilloscope to the appropriate test points.
2. Set and confirm the DME is set to use "X" channels and is in operational mode.
3. Use the oscilloscope to manually or automatically (depending on oscilloscope) measure the time between the 50 % amplitude point of the leading edge of the first RF pulse and the 50 % amplitude point of the leading edge of the second RF pulse.
4. Repeat the measurements with the transponder set to "Y" channels.
5. Use the measurements to verify the system meets requirements in paragraph 3.2.6.2.

4.5.2.6.3 RF Delay Time Variation.

Test equipment needed:
Test Set C
Oscilloscope

Verification procedures: Repeat the procedures for 4.5.2.6.2 and using the system instruction manual to induce the following conditions:

a) Input signal level having any value between –94 dBm and –79 dBm with an interrogation pulse rise time of 2.5 (±0.5) μs.

b) Input signal level of –79 dBm and –10 dBm with an interrogation pulse rise time of 0.10 (±0.10) μs.

c) Input signal level of –60 dBm with a variation of interrogation pulse rise time through the range of 0.20 to 0.80 μs and a total variation of 0.5 μs through the range of 0.80 to 3.0 μs.

d) Input signal level of –60 dBm with a variation in interrogation pulse rate frequency (PRF) from 2500 through the maximum transmission rate with an interrogation pulse rise time of 0.10 (±0.10) μs.

Confirm that the system meets the requirements in paragraph 3.2.6.3 for all the induced conditions.

4.5.2.6.4 Transponder Power Output.

Test equipment needed:
Peak power meter

Verification procedure: The following procedures will be conducted for the preset DME power levels of 100 watts and 1000 watts:

1. Connect a peak power meter to the transponder output.
2. Confirm the DME is in operational mode.
3. Take a measurement from the peak power meter.
4. Use the measurement to verify the system meets requirements in paragraph 3.2.6.4.

4.5.2.6.5 Pulse Power Variation.

Test equipment needed:
Oscilloscope

Verification procedure: The following procedures will be conducted for the preset DME power levels of 100 watts and 1000 watts. The peak power of the constituent pulses of any pair of pulses shall not differ by more than 1 dB.

1. Connect the oscilloscope to the appropriate test points to view the reply pulse pair.
2. Confirm the DME is in operational mode.
3. Measure the peak pulse power of the first pulse of the pulse pair and of the second pulse of the pulse pair.
4. Use the measurement to verify the system meets requirements in paragraph 3.2.6.5.

4.5.2.6.6 RF Pulse Signal Spectrum.

Test equipment needed:
Spectrum analyzer

Verification procedure: The following procedures will be conducted for the preset DME power levels of 100 watts and 1000 watts. The spectrum of the pulse modulated signal shall be such that during the pulse the effective radiated power contained in a 0.5 MHz band centered on frequencies 0.8 MHz above and 0.8 MHz below the nominal channel frequency in each case shall not exceed 200 mW, and the effective radiated power contained in a 0.5 MHz band centered on frequencies 2 MHz above and 2 MHz below the nominal channel frequency in each case shall not exceed 2 mW. The effective radiated power contained within any 0.5 MHz band shall decrease monotonically as the band center frequency moves away from the nominal channel frequency.

1. Connect the spectrum analyzer to the output of the system.
2. Confirm the DME is in operational mode.
3. Setup spectrum analyzer to give a signal spectrum similar to figure 8 (settings will vary with model of spectrum analyzer used). Resolution bandwidth around 30 kHz and video bandwidth around 100 kHz.
4. Locate the frequency +800 kHz from the center frequency and record a signal strength measurement.
5. Locate the frequency -800 kHz from the center frequency and record a signal strength measurement.

6. Locate the frequency +2 MHz from the center frequency and record a signal strength measurement.
7. Locate the frequency -2 MHz from the center frequency and record a signal strength measurement.
8. Use the readings to verify the system meets requirements in paragraph 3.2.6.6.

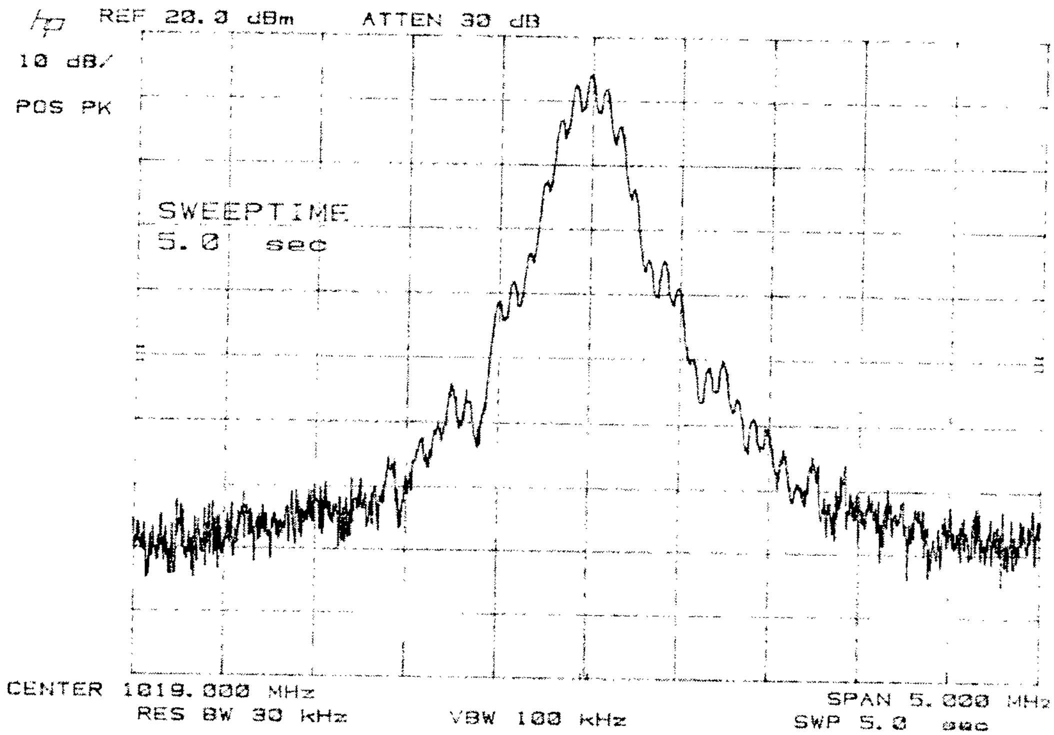

Figure 8. DME Signal Spectrum

4.5.2.6.7 Out-of-band Spurious Radiation.

Test equipment needed:
Spectrum analyzer

Verification procedure: The following procedures will be conducted for the preset DME power levels of 100 Watts and 1000 Watts.

1. Set up a spectrum analyzer connected to the output of the transponder with 40 dBm attenuation and then set trigger to FREE RUN. Watch for spurs caused by the spectrum analyzer.
2. Set the spectrum analyzer resolution and video bandwidths at 10 kHz each, set the span to 10MHz (settings may vary with model of analyzer).
3. Examine and (if possible) plot the spectrum of the output signal over the range of 10 MHz to 1800 MHz.
4. Record the level of the highest spur between 10 MHz and 960 MHz.
5. Record the level of the highest spur between 1215 MHz and 1800 MHz.

6. Use the measurements to verify the system meets requirements in paragraph 3.2.6.7.

4.5.2.6.7.1 Voltage Standing Wave Ratio (VSWR) Protection.

Verification procedures: A demonstration shall be performed to show that the system meets the requirements in paragraph 3.2.6.7.1.

4.5.2.6.8 Inter-pulse Output Level.
Test equipment needed:
Spectrum analyzer

Verification procedure:
1. Setup a spectrum analyzer using 30 dB of attenuation on the output of the transponder.
2. Set the center frequency of the spectrum analyzer to the output frequency of the transponder. Set the frequency span to 0 Hz, the Resolution bandwidth to 3 MHz, the Video bandwidth to 3 MHz, and the Sweep time to 10 or 20 μs. Push the video trigger button.
3. Add 20 dB of attenuation to the input of the spectrum analyzer.
4. Verify the transponder is enabled.
5. Use the Reference level control to set the pulse peaks at the top line of the display graticule. Move the display line to –60 db with respect to the top line (this will be –80 db when the 20 db attenuator is removed).
6. Remove the 20 dB attenuator and reconnect the cable.
7. Verify there is a 1 μs period between the pulses where the level is below 60 db (80 db) on the analyzer indicating the system meets the requirements of paragraph 3.2.6.8.

4.5.2.6.9 Retriggering of Transponder. See procedure 4.5.2.2.2.1.

4.5.2.6.10 Equivalent Isotropically Radiated Power (EIRP).
Test equipment needed: None.

Verification procedure: Calculations from vendor shall be reviewed to verify the system meets requirements in paragraph 3.2.6.10.

4.5.2.7 Stabilization of Performance Characteristics.
Test equipment needed:
Stop watch or equivalent.

Verification procedure:
1. During warm up the transponder shall be timed to measure the amount of time to arrive at a fully operational state.
2. Use the time measurement to verify the system meets requirements in paragraph 3.2.7.

4.5.2.8 Duty Cycle Overload Protection.
Test equipment needed: None

Verification procedure: Inspect the system instruction manual to verify the system meets requirements in paragraph 3.2.8.

4.5.2.9 Thermal Overload Protection.
Test equipment needed: None.

Verification procedure: Verify the system meets requirements in paragraph 3.2.9 by demonstrating the functionality of the equipment and reviewing the instruction book.

4.5.3 Antenna Requirements. The antenna shall be tested independently from the system to the requirements given in paragraph 3.3. The test shall be conducted at an appropriate antenna test facility, which may be the manufacturer's antenna test sight. This test shall be observed by government employees to assess validation of the procedures to meet the antenna requirements.

4.5.4 Monitor.

4.5.4.1 Operating Channels.
Test equipment needed:
See paragraph 4.5.2.1.

Verification procedure: The system instruction manual's appropriate test points to measure the monitor frequency will be used in the procedures given in paragraph 4.5.2.1.

4.5.4.1.1 Frequency and Accuracy Stability.
Test equipment needed: None.

Verification procedure: Verify the readings from paragraph 4.5.4.1 meet the requirements in paragraph 3.4.1.1.

4.5.4.2 Monitor RF Input/Output Signal Coupling.
Test equipment needed: None.

Verification procedure: Verify the system uses devices internal to the monitor hardware to sample the radiated power of the transponder through the antenna monitor probes and that the remaining monitoring functions are accomplished through the monitor probes or a coupler in accordance with paragraph 3.4.2

4.5.4.3 Interrogation Signal Generator.
Test equipment needed:
Interrogation Signal Generator (ISG)

Verification procedure: Utilize the ISG to demonstrate that proper interrogation signals are injected into the transponder monitor by performing the procedures given in paragraph 4.5.4.4 using only the ISG in place of test set C. Also demonstrate the ISG has the capability to measure and display interrogation signal parameters to verify compliance with the requirements stated in paragraph 3.4.3.

4.5.4.3.1 Operational Modes.

Verification procedures: Confirm that the system meets the requirements in paragraph 3.4.3.1 based on the procedures conducted for the interrogation signal generator paragraph 4.5.4.3.

4.5.4.3.2 Pulse Synchronization Output. Verified in paragraph 4.5.4.3.3.

4.5.4.3.3 RF Output Pulse Signal.

Test equipment needed:
Oscilloscope

Verification procedure: Using an oscilloscope and the system instruction book the pulse shape characteristics can be measured and recorded.

1. Connect the oscilloscope to the appropriate test points.
2. Confirm the DME is in operational mode.
3. Use the oscilloscope to measure (manually or automatically depending on oscilloscope) the pulse shape characteristics in the following paragraphs 4.5.4.3.3.1 through 4.5.4.3.3.4.
4. Use the measurements to verify the pulse shape meets requirements in paragraph 3.4.3.3.

4.5.4.3.3.1 Rise Time.

Verification procedure: The rise time shall be measured from the 10 % point to 90 % point of the rising edge. Pulse rise time shall not exceed 3 μs nor be less than 2.0 μs. Use the procedure from paragraph 4.5.4.3.3 to verify the requirements of paragraph 3.4.3.3.1.

4.5.4.3.3.2 Pulse Top.

Verification procedure: The instantaneous amplitude of the pulse shall not, at any instant between the point of the leading edge which is 95 percent of maximum amplitude and the point of the trailing edge which is 95 percent of the maximum amplitude, fall below a value which is 95 percent of the maximum voltage amplitude of the pulse. Use the procedure from paragraph 4.5.4.3.3 to verify the requirements of paragraph 3.4.3.3.2.

.

4.5.4.3.3.3 Pulse Duration.

Verification procedure: The pulse duration shall be measured from the 50 % point of the rising edge to the 50 % point of the falling edge. Tolerance shall be 3.5 μs plus or minus 0.5 μs. Use the procedure from paragraph 4.5.4.3.3 to verify the requirements of paragraph 3.4.3.3.3.

4.5.4.3.3.4 Decay Time. The decay time shall be measured from the 90 % point to 10 % point of the falling edge. Pulse decay time shall nominally be 2.5 μs but shall not be more than 3.0 μs nor be less than 1.5 μs. Use the procedure from paragraph 4.5.4.3.3 to verify the requirements of paragraph 3.4.3.3.4.

4.5.4.3.4 Pulse Coding.

Test equipment needed:
Oscilloscope

Verification procedure: Using an oscilloscope and the system instruction manual the pulse spacing can be measured and recorded. Pulses shall be coded in pairs with a spacing, as measured between the 50 percent maximum voltage amplitude point on the leading edge of the first RF pulse to the corresponding point on the leading edge of the second RF pulse, of (a) 12 (±0.2) μs for "X" channels or, (b) 36 (±0.2) μs for "Y" channels.

1. Connect the oscilloscope to the appropriate test points.
2. Confirm the DME is in operational mode.
3. Use the oscilloscope to manually or automatically (depending on oscilloscope) measure the time between the 50 % amplitude point of the leading edge of the first RF pulse and the 50 % amplitude point of the leading edge of the second RF pulse.
4. Use the measurements to verify the system meets requirements in paragraph 3.4.3.4.

4.5.4.3.5 Pulse Power Variation.

Test equipment needed:
Oscilloscope

Verification procedure: The peak power of the constituent pulses of any pair of pulses shall not differ by more than 0.5 dB.

1. Connect the oscilloscope to the appropriate test points to view the reply pulse pair.
2. Confirm the DME is in operational mode.
3. Measure the peak pulse power of the first pulse of the pulse pair and of the second pulse of the pulse pair.
4. Use the measurement to verify the system meets requirements in paragraph 3.4.3.5.

4.5.4.3.6 Detected RF Output Signal. (Validated in procedure 4.5.4.3.3.)

4.5.4.3.7 RF Pulse Spectrum.

Verification procedures: Repeat the verification procedures from paragraph 4.5.2.6.6 using the interrogation signal generator instead of the transponder and confirm the interrogation signal generator meets the requirements for paragraph 3.4.3.7.

4.5.4.3.8 Spurious Output.

Test equipment needed:
Spectrum analyzer

Verification procedure:

1. Set up a spectrum analyzer connected to the output of the transponder with 40 dBm attenuation and then set trigger to FREE RUN. Watch for spurs caused by the spectrum analyzer.
2. Set the spectrum analyzer resolution and video bandwidths at 10 kHz each, set the span to 10MHz (settings may vary with model of analyzer). Examine and (if possible) plot the spectrum of the output signal over the range of 10 MHz to 1800 MHz.
3. Record the level of the highest spur between 10 MHz and 960 MHz.
4. Record the level of the highest spur between 1215 MHz and 1800 MHz.
5. Use the measurements to verify the system meets requirements in paragraph 3.4.3.8.

4.5.4.3.9 Test RF Output Frequency.

Test equipment needed:
Frequency counter

Verification procedure: Using a frequency counter and the system instruction manual a test point or connector shall be used to measure the frequency of the interrogation signal generator at the nominal interrogation frequency, at +/-200 kHz and at +/-900 kHz with respect to the nominal interrogation frequency.

1. Connect the frequency counter to the appropriate test points.
2. Confirm the DME is in operational mode.
3. Take a measurement of the frequency counter for the nominal interrogation frequency.
4. Set the interrogation signal generator to the nominal interrogation frequency with an offset of +200 kHz. Take a measurement of the frequency counter for the offset signal.
5. Set the interrogation signal generator to the nominal interrogation frequency with an offset of -200 kHz. Take a measurement of the frequency counter for the offset signal.
6. Set the interrogation signal generator to the nominal interrogation frequency with an offset of +900 kHz. Take a measurement of the frequency counter for the offset signal.

7. Set the interrogation signal generator to the nominal interrogation frequency with an offset of -900 kHz. Take a measurement of the frequency counter for the offset signal.
8. Use these measurements to verify the interrogation signal generator meets requirements in paragraph 3.4.3.9.

4.5.4.3.10 RF Output Level Calibration.

Test equipment needed: None.

Verification procedure: Using the system instruction manual, verify the system meets the requirements of paragraph 3.4.3.10.

4.5.4.3.11 RF Output Level And Accuracy.

Test equipment needed:
Power meter

Verification procedure: Using a power meter and the system instruction manual connect the power meter to a connecter or test point to correctly confirm the output power with respect to the internal attenuation of the interrogation signal generator and the system.

1. Connect the power meter to the appropriate RF connector or test point.
2. Confirm the DME is in operational mode
3. Start the internal signal generator with a signal power of –80 dBm.
4. Take a reading from the power meter and compare to the setting for the interrogation signal generator. Use the reading to verify the setting of the internal attenuator.
5. Repeat step 4 with a signal power of 0 dBm.
6. Repeat step 4 with a signal power of –40 dBm.
7. Do several increments of 1 dBm and repeat step 4 for each increment.
8. Use the readings to verify the system meets requirements in paragraph 3.4.3.11.

4.5.4.4 Transponder Monitor.

Test equipment needed:
Test Set C
Timing system (i.e., stop watch)

Verification procedure: All monitored parameters will be set to primary alarms and taken out of tolerance using independent equipment. The time will be measured for Alarm delay and Monitor response. The thresholds will be set as per paragraph 3.4.4.2.

1. Connect test set C as needed during procedure to complete each step.
2. Confirm the DME is in operational mode.
3. Set the following parameters to primary alarm with the listed tolerances:
    a. Reply efficiency – not less than 70 %.
    b. Time delay - +/- 0.5 μs.
    c. Pulse spacing - +/-0.5 μs.
    d. Transmission rate – not less than paragraph 3.2.2.10.
    e. Radiated power – reduction of 3 dB.

   f. Identification – absence of or continuous.
   g. Transponder frequencies - +/- 0.001 %
4. Use test set C to take reply efficiency out of tolerance.
5. Time the duration the parameter is out of tolerance until an alarm is registered by the system.
6. Note the action taken by the monitor after the alarm is registered.
7. Use test set C to return reply efficiency to with in tolerance conditions.
8. Set the DME to operational mode and time the duration until all fault and alarm indications end.
9. Repeat steps 4 to 8 for each parameter in step 3.
10. Use the readings and notes to verify the system meets requirements in paragraphs 3.4.4.1, 3.4.4.1.1, 3.4.4.1.2, and 3.4.4.2.1.

4.5.4.4.1 Monitor Alarm Action. See procedure in paragraph 4.5.4.4.

4.5.4.4.1.1 Alarm Delay Time. See procedure in paragraph 4.5.4.4.

4.5.4.4.1.2 Monitor Response Time. See procedure in paragraph 4.5.4.4.

4.5.4.4.2 Monitored Parameter Fault Thresholds.

4.5.4.4.2.1 Required Parameters. See procedure in paragraph 4.5.4.4.

4.5.4.4.3 Test Signals and Monitoring Activities.

Test equipment needed:
Frequency counter

Verification procedure: Utilize the frequency counter to verify that the monitor does not interrogate the transponder more than 120 ppps.

1. Connect the frequency counter to the appropriate test points to count the number of valid interrogations to the transponder.
2. Confirm the DME is in operational mode.
3. Confirm the DME is not running any additional test.
4. Collect data from the frequency counter at a time when there is no identification transmitted.
5. Use this data to verify that the system meets the requirements in paragraph 3.4.4.3.

4.5.5 Control / Status/ Indicator Functions.

Test equipment needed:
Test Set C

Verification procedure: The DME system shall provide control / status / indicator functions for the local and remote environments as defined in paragraph 3.5. Each requirement must be demonstrated by the DME system in the local environment, remote environment, or both as required by paragraph 3.5.

4.5.6 Remote Monitoring System.

Test equipment needed:
RMM

Verification procedure: The remote monitoring system will be verified by demonstrating that the requirements given in the paragraphs 3.6 and 3.6.1 can be performed by the DME system. Some requirements will be verified in paragraph 4.5.5.

5.0 PACKAGING

5.1 Packaging. - Packaging requirements shall be as specified in the contract.
5.2

6.0 NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Definitions. The following terminology used in this specification is defined below.

6.1.1 Interrogation Signal. The term interrogation signal denotes a signal having the characteristics identified in the subparagraphs below.

6.1.1.1 Radio Frequency. The center radio frequency of the interrogation signal is within 0.01 percent of the interrogation frequency for the channel in use.

6.1.1.2 Radio Frequency Pulse Spectrum. The RF spectrum of the interrogation signal is such that not less than 90 percent of the energy in each pulse is within a 500 kHz band centered on the channel interrogation signal frequency and in which each additional lobe of the spectrum is of lesser amplitude than the adjacent lobe nearer the channel frequency

6.1.1.3 RF Pulse Shape. The RF envelope of each pulse, as detected by a linear detector, has a shape falling within the limits set forth in the subparagraphs hereto.

6.1.1.3.1 Pulse Rise Time. The pulse rise time from the 10 percent point to the 90 percent point of the maximum voltage amplitude on the leading edge of the pulse.

6.1.1.3.2 Pulse Top. The instantaneous amplitude of the pulse does not, at any instant between the point on the leading edge which is 95 percent of the maximum voltage amplitude and the point on the trailing edge which is 95 percent of the maximum voltage amplitude, fall below a value which is 95 percent of the maximum voltage amplitude.

6.1.1.3.3 Pulse Duration. The pulse duration, from the 50 percent point of the maximum voltage amplitude on the leading edge of the pulse to the 50 percent point of the maximum voltage amplitude on the trailing edge of the pulse.

6.1.1.3.4 Pulse Decay Time. The pulse decay time, form the 90 percent point to the 10 percent point of the maximum voltage amplitude on the trailing edge of the pulse.

6.1.1.4 Pulse Coding. Pulses are coded in pairs with a spacing as measured between the 50 percent maximum voltage amplitude point on the leading edge of the first RF pulse to the corresponding point on the leading edge of the second RF pulse.

6.1.1.5 Interrogation Rate. The pulse pair rate for each interrogation signal is not less than 10 nor more than 150 ppps.

6.1.2 Transponder Reply Delay Time. For the purposes of this specification, reply delay time is defined as the time in μs of all delay introduced by the DME ground station in transmitting a pair of reply pulses in response to an interrogation signal. The reply delay time is measured from the 50 percent maximum voltage amplitude point on the leading edge of the first constituent RF pulse of the interrogation pulse pair to the corresponding point on the first constituent RF pulse of the reply pulse pair. (Note that first pulse timing is involved which will require retention of the time of the 50 percent amplitude point of the leading edge of the first pulse pending decode or pulse spacing validation. The nominal values of reply delay are 50 μs for X channel and 56 μs for Y channel.)

6.1.3 Squitter. Randomly occurring pulse pairs generated within the transponder as required to maintain a minimum output pulse count of 750 ppps. As the number of replies to aircraft interrogations increases, the number of squitter pulses is automatically reduced to maintain the minimum output pulse count at the specified level.

6.1.4 Automatic Gain Reduction (AGR). A feature of the transponder which automatically reduces the sensitivity of the receiver to limit the number of replies to interrogations to a specified maximum.

6.1.5 Receiver Sensitivity. That level of interrogation signal as measured at the antenna input terminals of the ground station transponder which results in 70 percent replies to the interrogation signal. The terms "receiver sensitivity" and "receiver threshold triggering level" are often used interchangeably.

6.1.6 Receiver Threshold Triggering Level. As used herein refers to the receiver sensitivity in the absence of traffic loading resulting in AGR or reduction in reply efficiency due to echo suppression blanking.

6.1.7 Reply Efficiency. The percentage of replies provided by the transponder to an interrogation signal of a given level. The maximum reply efficiency is limited by the number of receiver output pulses (squitter plus replies) and the receiver dead time.

6.1.8 Receiver Dead Time. A period of time (nominally 60 μs) following the decoding of an interrogation pulse pair (and encompassing the time occupied by the transmittal of a reply pulse pair) during which the receiver is prevented from decoding a following interrogation pulse pair.

6.1.9 Echo Suppression. A feature of the transponder intended to prevent multiple replies as the result of echoes in the interrogation (air-to-ground) path.

6.1.10 Equivalent Isotropically Radiated Power (EIRP). The product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain).

6.1.11 Control. A "control" can be either a physical switch or a function controlled by a connected computer.

6.1.12 Continuous Wave (CW). A continuous wave or continuous waveform (CW) is an electromagnetic wave of constant amplitude and frequency; and in mathematical analysis, of infinite duration.

6.1.13 Electromagnetic Interference (EMI). Any emitted, radiated, conducted, or induced voltage that degrades, obstructs, or interrupts the desired performance of electronic equipment.

6.2 DME Compliance to ICAO Annex 10 Matrix.

Table 2. ICAO Annex 10 Compliance Matrix

ICAO Annex 10 Para No.	Paragraph Title	DME Spec Para No.	Comments
3.5.1	Definitions	6.1	
3.5.2	General	3.1	
3.5.2.1	DME Purpose	3.8	
3.5.3	System Characteristics	3.7	
3.5.3.1	Performance	3.7	
3.5.3.1.1	Range	3.7.1	
3.5.3.1.2	Coverage	3.1.10	
3.5.3.1.3	Accuracy	3.1.11	
3.5.3.1.3.1	System Accuracy	3.1.11.1	
3.5.3.1.3.2	DME/N Accuracy	3.1.11.2	
3.5.3.1.3.2	Total System Error	3.1.11.2	
3.5.3.2	Radio Frequencies and Polarization	3.3.2 3.3.3	
3.5.3.5	Aircraft Handling Capacity of the System	3.1.11.3	
3.5.3.6.1	Identification Signal Form	3.2.3	
3.5.3.6.2	Identification Signal Structure	3.2.3	
3.5.3.6.2.1	Transmit Time	3.2.3	
3.5.3.6.2.2	Identification Duty Cycle	3.2.3	
3.5.3.6.3	Independent Identification Signal Characteristics	3.2.3.3	
3.5.3.6.4	Associated Identification Signal Characteristics	3.2.3.4	
3.5.3.6.5	Identification Implementation	3.2.3.5	
3.5.4	Detailed technical characteristics of transponder and associated monitor	3.2	
3.5.4.1	Transmitter	3.2.4	
3.5.4.1.1	Frequency of operation.	3.2.1	
3.5.4.1.2	Frequency Stability	3.2.1.1	
3.5.4.1.3	Pulse Shape and Spectrum	3.2.6.1 3.2.6.6	
3.5.4.1.4	Pulse Spacing	3.2.6.2	
3.5.4.1.5	Peak Power Output	3.2.6.4	
3.5.4.1.5.2	EIRP	3.2.6.10	
3.5.4.1.5.4	Peak Power of Constituent Pulses	3.2.5.6	
3.5.4.1.5.6	Transmission Rate	3.2.2.9	
3.5.4.1.6 3.5.4.1.6.1	Spurious Radiation	3.2.6.8	
3.5.4.1.6.3	Out-of-Band Spurious Radiation	3.2.6.7	
3.5.4.1.6.4	CW EIRP	3.2.2.6.1.4	
3.5.4.2	Receiver	3.2.2	
3.5.4.2.1	Frequency of Operation	3.2.1	
3.5.4.2.2	Frequency Stability	3.2.1.1	
3.5.4.2.3	Transponder Sensitivity	3.2.2.6	
3.5.4.2.3.1	Peak Power Density	3.2.2.6	
3.5.4.2.3.2	Reply Efficiency	3.2.2.6	
3.5.4.2.3.3	Dynamic Range	3.2.2.6.3	
3.5.4.2.3.5	Sensitivity Level Variation	3.2.2.6.1.1	
3.5.4.2.3.6	Spacing of an interrogator pulse pair varies from the nominal value	3.2.2.6.1.2	
3.5.4.2.4.1	Sensitivity Reduction	3.2.2.10	
3.5.4.2.5	Noise Generated Pulse Pairs	3.2.2.6.4	
3.5.4.2.6	Bandwidth	3.2.2.1.1	
3.5.4.2.6.1	Minimum Permissible Bandwidth	3.2.2.1	

ICAO Annex 10 Para No.	Paragraph Title	DME Spec Para No.	Comments
3.5.4.2.6.5	Signals Greater than 900 kHz Removed	3.2.2.6.2 3.2.2.8	
3.5.4.2.7	Recovery Time	3.2.2.4	
3.5.4.2.9	CW and Echo Suppression	3.2.2.5	
3.5.4.2.10	Protection Against Interference	3.2.2.6.1.4 3.2.2.8	
3.5.4.3	Decoding	3.2.2.2	
3.5.4.3.1	Decoding Circuit	3.2.2.2	
3.5.4.3.2	Decoding Circuit Performance	3.2.2.2.1	
3.5.4.3.3	Decoder Rejection	3.2.2.2.2	
3.5.4.4	Time Delay	3.2.4.3	
3.5.4.4.1	Associated with ILS	6.1.2	
3.5.4.4.3	Time Delay Adjustment	3.2.4.3	
3.5.4.4.3.1	Time Delay Definition	6.1.2	
3.5.4.5	Accuracy	3.1.11	
3.5.4.5.1	Overall System Accuracy	3.1.11.1	
3.5.4.5.2	System Accuracy with Associated Landing Aid	3.1.11	
3.5.4.6	Efficiency	3.2.2.7	
3.5.4.6.1	Reply Efficiency	3.2.2.7	
3.5.4.6.2	Transponder Dead Time	3.2.2.3	
3.5.4.7	Monitoring and Control	3.4, 3.5	
3.5.4.7.2	DME/N Monitoring Action	3.4.4	
3.5.4.7.2.1	Monitoring Action	3.4.4.1	
3.5.4.7.2.2 3.5.4.7.2.3 3.5.4.7.2.4	Monitor Alarms	3.4.4.2 3.4.4.2.1 3.4.4.2.2	
3.5.4.7.2.5	Alarm Delay Time	3.4.4.1.1	
3.5.4.7.2.6	Transponder Triggering	3.4.4.3	

6.3 Acronym List

AGR	Aiutomatic Gain ReductionRedictopm
CW	Continuous Wave
DME	Distance Measuring Equipment
DoD	Department of Defense
DoDISS	Department of Defense Index of Specifications and Standards
DQT	Design Quality Test
EIRP	Equivalent Isotropically Radiated Power
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
FCC	Federal Communication Commission
HMI	Hazardous or misleading information
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
MIT	Monitor Integrity Test
MTBF	Mean Time Between Failures
NAS	National Airspace System
OS	Operating System
Ppps	pulse pairs per second
LED	Light-Emitting Diode
LRU	Lowest Replaceable Unit
PAT	Production Acceptance Test
RF	Radio Frequency
RMM	Remote Maintenance Monitoring
RMS	Remote Monitoring System
TT	Type Test
VHF	Very High Frequency
VOR	Very High Frequency Omnidirectional Range
VRTM	Verification Requirements Traceability Matrix
VSWR	Voltage Standing Wave Ratio